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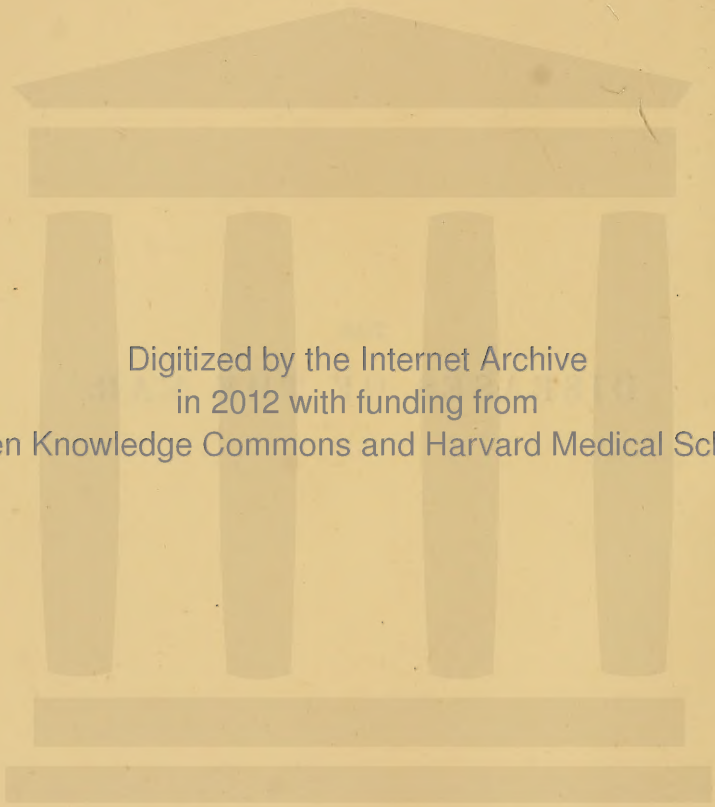
DISEASES OF THE EAR.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A TEXT-BOOK

OF THE

DISEASES OF THE EAR

AND ADJACENT ORGANS.

BY

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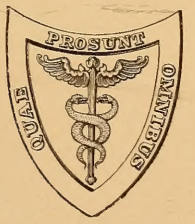
WITH 330 ORIGINAL ILLUSTRATIONS.



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1894.

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PREFACE.

THE thorough knowledge of the German and English languages possessed by Dr. Dodd ensures to the English-speaking part of the medical profession an accurate translation of Professor Politzer's Text Book.

To knowledge Dr. Dodd has added great care, so that the translation is more than accurate—it is excellent.

As a treatise on diseases of the ear it is complete, since it embraces all that is known on the subject.

When questions in surgery are *sub judice* they are discussed in the calm and dispassionate manner that might be expected from the talented and well-known author. The revision of such a work, as it has passed through the press, has been a sincere pleasure to the editor.

W. B. DALBY.

TO THE TRANSLATOR.

VIENNA, *July* 21*st*, 1893.

DEAR DR. DODD,

You were so kind as to take charge of the translation of the Third Edition of my Text-book, and this work being now accomplished, I am anxious to express to you my full approbation of all the particular care and conscientiousness of which you made proof in the clear conception and reproduction of all the scientific terms in the work.

I thank you with all my heart, and beg you will accept my fervent congratulations for the laborious zeal with which you performed this arduous and difficult task, as well as my sincere compliments for the attained success.

Assuring you once more of my grateful appreciation, I am, with kind regards,

Yours very truly,

ADAM POLITZER.

TO THE EDITOR.

VIENNA, *July* 21*st*, 1893.

DEAR SIR WILLIAM DALBY,

I am conscious that I am indebted to your particular benevolence for editing Dr. Dodd's translation of the Third Edition of my *Text-book on the Diseases of the Ear*.

I make no doubt that it is owing to your assistance, and your genial and frequent inspirations, that the work has so well succeeded.

Your eminent position amongst aural Surgeons is a sure guarantee that the work will be favourably received by our English colleagues.

Allow me, therefore, to express to you my gratification, and to thank you most heartily for the personal interest you were so kind as to take in the success of this work.

Let me assure you that I shall always remember your benevolent assistance in this enterprise, and believe me, dear Sir William,

Yours most truly,

ADAM POLITZER.

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ANATOMICAL DIVISION OF THE EAR.

The sensations which we call perceptions of sound reach our consciousness by the specific excitation of the peripheral expansion of the auditory nerve. The delicate terminations of this nerve lie upon membranous supports, which are surrounded by an aqueous fluid in a cavity partly formed by rigid walls. These membranous supports serve as a medium for the transfer of the waves of sound, which reach the organ of hearing from the outer world, to the extremities of the auditory nerve.

Beside the essential sound-perceiving apparatus, the higher developed animals possess a sound-conducting apparatus which possesses the property of receiving and conducting to the labyrinth the different sound-waves.

According to the above observations, the organ of hearing is divided into two principal parts, the sound-conducting and the sound-perceiving portions. As this classification is the only correct one from the physiological standpoint, we will adhere to it for the future, especially as the older anatomical divisions into *outer*, *middle*, and *inner ear* can be reconciled with it.

After dividing the organ of hearing, then, into two principal parts, as mentioned above, a further division takes place as follows:

1. *The sound-conducting apparatus*, in:
   - *a*. The external ear (auricle and external meatus).
   - *b*. The middle ear (the tympanic cavity with membrana tympani and ossicula, Eustachian tube and mastoid process).

2. *The sound-perceiving apparatus*, the internal ear (labyrinth), which consists of the vestibulum, the three semicircular canals, and the cochlea, in which latter the peripheral expansions of the auditory nerve are found.

THE ANATOMY AND PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS.

I. THE EXTERNAL EAR.

A. The Auricle.

The auricle presents in its outline a pyriform shape. Its normal position is between two horizontal lines, of which the superior touches the eyebrows, the inferior the tip of the nose. While it surrounds the external orifice of the ear, it is fastened on the lateral part of the head, midway between the forehead and the occiput, in such a manner that it forms with the lateral part of the head towards the occiput an acute angle, which is subject to manifold individual varieties.

In this position the concave surface of the auricle, turned forwards and outwards, shows a number of irregular elevations and depressions (Fig. 1). The outer margin of the cartilaginous plate is turned in towards the front, and forms the *helix* of the auricle (Fig. 1, *a*). The helix, commencing at the *crista helicis*, above the external orifice of the ear, in the most pronounced depression of the auricle (*concha*), extends from here along the margin of the auricle upwards and backwards, and ends as processus helicis above the posterior margin of the lobe. In parallel direction with the posterior part of the helix, and separated from it by a depression, the so-called *scaphoid fossa*, there extends a second elevation, the *antihelix* (*b*). It commences above the crista helicis with two crura diverging forwards (*crura bifurcata*), and taking its course downwards, it passes with a slight curve forwards into a prominence of cartilage, the so-called *antitragus* (*d*). Opposite to the last-named part, and in front of the external orifice of the meatus, surmounting it a little, the cartilage of the ear forms a second nipple-like projection directed backwards, the *tragus* (*c*), which is separated from the antitragus by a notch (*incisura intertragica*). Below this notch, forming the inferior extremity of the auricle, is the lobe (*lobulus*, *e*), which shows numerous individual varieties, and in whose formation only the integument covering the auricle takes part.

The subcutaneous connective tissue is highly developed in this place, its meshes containing globules of fat, but only a small number of bloodvessels and nerves.

The *external integument*, covering the auricle, is fastened much more tightly to the perichondrium on the anterior than on the convex posterior surface, where the subcutaneous connective tissue is more strongly developed, and the skin therefore more easily movable. Of the cutaneous glands the sebaceous are very numerous in the concha, and are also of a large size. The cartilage of the auricle is about 2 mm. in thickness, and is of the reticulated variety.

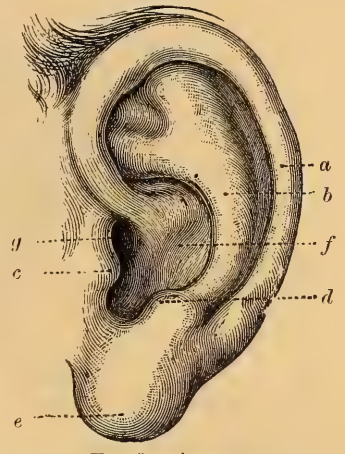

FIG. 1.—AURICLE.

a, Helix; *b*, Antihelix; *c*, Tragus; *d*, Antitragus; *e*, Lobulus; *f*, Concha; *g*, Orifice of the external meatus.

The muscles supplying the auricle are divided into two groups. The first group acts in such a manner that it effects a movement of the whole auricle. The most important muscles belonging to this group are: 1. The *attollens auriculæ*, a fan-shaped radiating muscle, which arises from the epicranial aponeurosis, and with its fibres converging in a downward direction, attaches itself to the convex surface of the auricle; it draws the auricle upwards. 2. The *attrahens auriculæ*, which arises also from the epicranial aponeurosis in front of the auricle, above the zygomatic arch, and has its place of attachment on the crista helicis; it draws the auricle a little forwards and upwards. 3. The *retrahens auriculæ*, which arises behind the auricle on the mastoid process, consists of several fasciculi, and extends to the convex surface of the concha; it is intended to draw the auricle a little backwards. The second group of muscles have their origin and place of attachment on the auricle itself. They effect an alteration in the form of the auricle, but only to a slight extent. The *tragicus*, *antitragicus*, *helicis major* and *minor* lie on the concave surface, the *transversus* and *obliquus auriculæ* on the convex surface of the auricle.*

B. The External Meatus.

The external meatus is divided into two portions, viz., the cartilaginous and the osseous.

* 'The new criminalistic school of Italy, of which Lombroso is at the head, consider the anomalies in the form of the ear as degenerative changes. Support is found for this view by the extensive investigations lately made by Gradenigo (A. f. O., vol. xxx.), in which he found the anomalies of conformation of the auricle most frequent among the insane and criminals.'

a. Its Cartilaginous Portion.

The cartilaginous meatus is a tubular continuation of the auricle directed inwards. This canal, however, is not cartilaginous in its whole extent, but consists of a cartilaginous channel, which is formed at its upper and back part into a tube by a membranous layer connected with the lining membrane of the meatus.

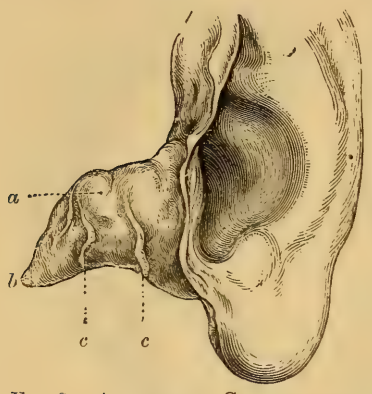

FIG. 2.—AURICLE AND CARTILAGINOUS MEATUS.

a, Cartilaginous meatus : *b*, Interior pointed extremity of the cartilaginous meatus ; *c*, *c*, Fissures of Santorini (left ear).

The circumference of the cartilaginous channel (Fig. 2) appears largest at its outer extremity, while inwards the width of the cartilage gradually decreases, so that the inner extremity (*b*) appears as a narrow, rounded, cartilaginous point.

This proportion of the cartilaginous channel to the membranous part of the passage can be shown in a simple manner by sections (Figs. 3, 4, 5) which are made perpendicularly to the axis of the cartilaginous meatus at the outer, middle, and inner portions. We see, therefore, that the membranous portion (*b* in Figs. 3, 4, 5) increases in breadth towards the interior, while the cartilage decreases. The length of the lower cartilaginous wall from the entrance of the meatus to the point of the cartilage varies from 10 to 11 mm.

The channel of the cartilaginous portion of the meatus, which varies in thickness in different places from 1 to 3 mm., is traversed transversely by

FIG. 3.—SECTION OF THE CARTILAGINOUS MEATUS CLOSE BEHIND THE ORIFICE OF THE EXTERNAL MEATUS.

a, *a*, *a*, Cartilaginous channel ; *b*, Fibrous layer.

FIG. 4.—SECTION THROUGH THE MIDDLE OF THE CARTILAGINOUS MEATUS.

a, *a*, *a*, Cartilaginous channel ; *b*, Fibrous layer.

FIG. 5.—SECTION IN THE NEIGHBOURHOOD OF THE INTERIOR EXTREMITY OF THE CARTILAGINOUS MEATUS.

a, Cartilage ; *b*, Fibrous layer.

several fissures, the so-called fissures of Santorini (Fig. 2, *c*, *c*). As a rule, two large fissures are found. These are, however, by no means regular and constant in direction or extent. They are filled up by a fibrous tissue, which often contains small bundles of muscular tissue, and allows an anastomosis of

the bloodvessels between the anterior and posterior surfaces of the ear. They are important because they favour the straightening of the meatus during the examination of the membrana tympani and during operations.

But in other respects also the fissures of Santorini possess a practical interest. The inferior wall of the cartilaginous channel of the meatus is to a great extent surrounded by the lobes of the parotid, so that in a parotitis, ending in abscess, the accumulated pus may force its way through one of these fissures into the external meatus. The medial end of the cartilaginous meatus is fastened by means of a mass of connective tissue to the osseous meatus, covered over with elastic fibrous tissue. This consolidation, however, takes place only in that part of the external meatus formed by the tympanic portion of the temporal bone, which we have still to describe; therefore it belongs to the inferior and lateral margin of the canal (Fig. 8), while above, where the squamous portion curves at a right angle towards the superior wall, the fibrous portion of the cartilaginous meatus passes without interruption into the lining membrane of the superior wall of the osseous meatus.

b. Osseous Meatus.

1. *Its Development.*—The anatomical relations of the osseous meatus are essentially different in the new-born infant and in the adult. In the infant we find, instead of the osseous meatus, an osseous ring (*annulus tympanicus*) to the exterior margin of which a membranous canal (v. Tröltsch) is attached, forming one half of the whole meatus. This part ossifies from within outwards during the early years of life.

The formation of the osseous meatus is essentially connected with the development of the temporal bone. According to the examinations made by Arnold, the temporal bone is divided into three parts, which are separately developed. These are called the squamous, the tympanic, and the petrous portions of the temporal bone. The osseous meatus consists of two different parts, and is principally formed by the squamous and tympanic portions of the temporal bone.*

The tympanic portion of the temporal bone in a child consists of a ring (annulus tympanicus) (Fig. 6) with an opening upwards and forwards, and is provided with a groove for the reception of the membrana tympani. This ring is attached by its free extremities to the inferior part of the exterior surface of the squamous portion. The space between the two places of attachment of the tympanic portion to the squamous portion we shall know by-and-by as the anterior superior grooveless segment of the tympanic ring (Rivinian segment).

* In Du Verney's *Traité de l'Organe de l'Ouie*, 1731, plate iv., the perfect os tympanicum as principal constituent of the osseous meatus in the adult will be found represented either in connection with the temporal bone or by itself. In the same book, plate xv., there is a representation of the lately-discovered *sutura mastoideo-squamosa*.

With the progressing growth of the cranial bones in the early years of life, the following alterations take place in the squamous and tympanic portions. While (Fig. 7) the superior part of the squamous portion is placed on the

FIG. 6A.

FIG. 6B.

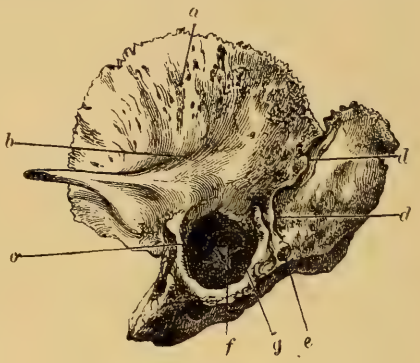

FIG. 7.—TEMPORAL BONE IN THE NEW-BORN INFANT.

a, Superior part of the squamous bone ; *b*, Its inferior part below the line of the zygomatic process ; *c*, Annulus tympanicus ; *d*, *d*, The fissure between squamous portion and mastoid process, reaching to the foramen stylo-mastoideum ; *e*, Foramen stylo-mastoideum ; *f*, Foramen ovale ; *g*, Foramen rotundum (left ear).

lateral part of the cranium, its lower portion (*b*), which lies beneath the line of the zygomatic process, takes a more horizontal position, in such a way that in the completely developed temporal bone the superior part of the squamous portion (Fig. 9, *a*) is bent almost at a right angle to its inferior horizontal portion (*b*). This horizontal portion forms the superior wall of the osseous meatus, and in conjunction with the mastoid process it also forms a part of the posterior wall.

FIG. 8.—OSSEOUS MEATUS IN THE ADULT.

a, Horizontal part of the squamous bone (superior part of the meatus) ; *b*, Tympanic portion ; *c*, Lumen of the meatus ; *d*, Mastoid process (left ear).

As mentioned above, an essential part in this formation of the osseous meatus is taken by the tympanic portion of the temporal bone. With its growth, through deposit of osseous substance on its exterior (Zuckerkandl), there arises an osseous groove (Fig. 8, *b*), the lateral walls of which reach so far up in a median direction near to the tympanic bone, that they also take part to a varying extent in the formation of the superior wall of the meatus.

In the perfect temporal bone, therefore, the groove-like tympanic portion (Fig. 8) appears as if pushed from below into the shallow sulcus (*a*) which, directed downwards, is formed by the horizontal part of the squamous bone and the mastoid process. The inferior and anterior walls of the meatus are therefore formed by the tympanic portion, while in the formation of the posterior wall the squamous, mastoid and tympanic portions participate, the first largely by the lamina mastoidea, which lies on the anterior surface of the mastoid process.

Sometimes the tympanic portion lies so close to the squamous portion and mastoid process, that their boundary lines appear almost effaced; sometimes the margin of the tympanic portion is prominently set off from the squamous portion and the mastoid process. Into the fissures thus formed prolongations of connective tissue descend, into which inflammatory and suppurative processes sometimes penetrate, causing caries of the wall of the meatus. On the other hand, in purulent affections of the meatus, I have seen the destructive process spread through these fissures from the inside outwards, in which case a loosening and detachment of the lining membrane of the posterior and superior walls of the meatus took place.

2. *Construction of the Osseous Meatus.*—The osseous portion of the external meatus comes into connection with the cartilaginous meatus at its exterior margin, while at its interior, widened extremity, the membrana tympani is stretched out in a groove-like sulcus. We distinguish in it an upper, lower, anterior, and posterior wall.

The strongly developed superior wall of the meatus (Fig. 9, *b*) appears bent almost at a right angle to the squamous portion (*a*) of the temporal bone, and is formed by two osseous plates, the superior of which is turned towards the cranial cavity, and the inferior towards the lumen of the meatus.

Of these plates, the upper one meets at the *sutura petroso-squamosa* with the superior wall of the tympanic cavity, and further back with the roof of the mastoid antrum; the lower reaches to the boundary of the tympanic cavity, where it ends abruptly in a sharp grooveless edge (*margo tympanicus* of the temporal bone), directed inwards and downwards, into which the upper margin of the membrana tympani is inserted.

The superior wall of the meatus lies in the region of the middle fossa of the skull, so that carious destruction of this wall, with extension to the meninges, may produce death.

The inferior wall of the osseous meatus (*c*) appears thick and compact in the section. Its surface turned towards the meatus is convex from without inwards, the greatest convexity being on the borders of the inner third of the wall of the osseous meatus, from whence the surface inclines rather steeply towards the outside as well as towards the inside. In the neighbourhood of the membrana tympani the convexity is turned into a considerable concavity (Fig. 9), which deserves notice, because it, in conjunction with the membrana tympani, the latter placed obliquely to the axis of the meatus, forms a space

(sinus of the external meatus, H. Meyer), in which small foreign bodies are often lodged.

A comparison of the lengths of the superior and inferior walls of the meatus shows that the superior wall extends farther outwards than the inferior, but that the inferior (*c*) extends from 6-8 mm. nearer the middle line of the body than the superior (*b*). By this, as well as by the unequal lengths of the anterior and posterior walls, the oblique position of the membrana tympani to the axis of the meatus is caused: a fact which must be taken into consideration at the examination of the membrana tympani, as well as at operations.

The anterior wall (Fig. 10, *a*), compared with the other, is thinner, and in

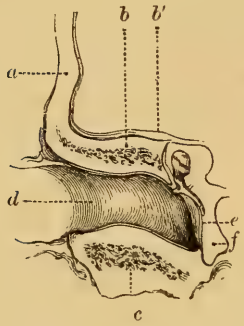

FIG. 9.—PERPENDICULAR SECTION (FRONT) THROUGH OSSEOUS MEATUS AND TYMPANIC CAVITY.

a, Squamous portion; *b*, Superior wall of the osseous meatus; *b'*, Dura mater; *c*, Inferior wall of the osseous meatus; *d*, Meatus; *e*, Membrana tympani with the malleus; *f*, Tympanic cavity (left ear).

FIG. 10.—HORIZONTAL SECTION OF THE EXTERNAL MEATUS AND TYMPANIC CAVITY.

a, Anterior wall of the meatus; *b*, Posterior wall; *c*, Cells of the mastoid process; *d*, Meatus; *e*, Membrana tympani; *f*, tympanic cavity; *g*, Sinus transversus.

its longitudinal direction, especially at the boundary of the inner third, is more or less strongly bulged out towards the lumen of the meatus. It is 17-18 mm. long, and extends inwards 7 to 8 mm. farther than the posterior wall.

The defects in the anterior wall of the meatus, which are seen during the earlier years of life, arise, according to Zuckerkandl, from the rapid growth of the tuberculum anterior and posterior of the tympani ring. By a bridge-like union a space is formed, which, however, generally closes at the end of the third year. Defects in the ossification are not infrequently met with in the temporal bones of adults (Arnold, v. Trolsch).

The inner part of the cartilaginous meatus and the anterior wall of the bony meatus lie immediately on the posterior part of the glenoid cavity. The movement of the jaw produces thereby a change in the lumen of the cartilaginous meatus. Violence applied to the lower jaw may produce fracture of the anterior osseous wall of the meatus.

The posterior wall of the osseous meatus is chiefly formed, in its inner portion, by the tympanic portion of the temporal bone, its exterior portion,

however, being formed by the mastoid process. It extends farther outwards than the other walls, especially the inferior and anterior.

During the growth of the temporal bone the cells of the mastoid process extend outwards along with the greater mass of the cellular spaces by lying behind the meatus. Towards the front the mastoid cells are, therefore, immediately covered by the posterior wall of the osseous meatus, from which the important relation of this wall to the mastoid process can be understood, since caries in the latter often extends to the posterior wall, the necrosed cells being cast out through the external meatus.

c. The Lining Membrane of the External Meatus.

The lining membrane of the external meatus, a continuation of the external integument, is much stronger in the cartilaginous than in the osseous portion. In the latter the cutis generally becomes more delicate and thin as it gets nearer the sulcus of the membrana tympani; only on the superior wall a somewhat stronger band of the cutis extends towards the membrana tympani. The dermic layer of the cartilaginous portion, 1-2 mm. in thickness, is plentifully supplied with hairs, into the sacs of which grape-like sebaceous glands discharge themselves. Near these glands, embedded in the subcutaneous tissue, and closely applied to each other, are the so-called ceruminal glands (*glandulæ ceruminales*, sweat-glands of the ear, according to Ausspitz) of a yellowish-brown colour, which in their formation belong to the tubular glands. Just as in the sweat-glands in other parts, the tube of these ceruminal glands is coiled up (Kölliker); it is 0·2 to 1·5 mm. in diameter, and discharges either directly into the meatus, or into the upper portion of the hair-sacs by means of a straight canal, 0·1 mm. wide (Henle). The orifices of the glands in the meatus can be observed with the naked eye as closely arranged small darkish points (Fig. 11, *a*, *b*, *c*). These glands are constructed of a single layer of cubical epithelium, outside of which is a membrana propria and a layer of smooth muscular fibres.

FIG. 11.—POSTERIOR WALL OF THE CARTILAGINOUS AND OSSEOUS MEATUS.

a, Orifices of glands on the cartilaginous portion; *b*, Boundary between cartilaginous and osseous meatus; *c*, Termination of the triangular space occupied by the orifices of the glands, which protrudes into the osseous meatus.

According to v. Tröltsch, the glandular layer extends from the posterior superior wall of the cartilaginous portion into the osseous meatus in the form of a triangular space, several mm. long (Fig. 11, the place between *b*, and *c*), the point of which (*c*) is turned towards the membrana tympani. In the other

parts of the osseous meatus the glandular elements are wanting, and the more delicate cutis, firmly united with the periosteum, forms spirally-arranged ridges (Kaufmann), lying close together and containing only a few papillæ (Medic. Jahrbücher, 1866), which often become hypertrophied in inflammatory affections, and form the foundation of large compact polypi.

d. Vessels and Nerves of the Auricle and of the External Meatus.

The arteries of the auricle and of the external meatus spring from the temporal and internal maxillary arteries. The anterior surface of the auricle, as well as the exterior portion of the meatus, are supplied by the *art. auric. ant. sup.* and two to three *art. auric. anteriores inferiores*, springing from the *art. temporal. superf.* A branch of the *art. auric. posterior*, springing from the external carotid, ramifies on the posterior surface of the auricle. The blood-supply to the lower portions of the external meatus is provided by the *art. auric. profunda*, a branch of the *art. maxillaris interna.* The smaller branches of the above-named arteries enter partly the intermediate membranous layer, bridging over the margins of the cartilaginous groove, partly the fissures of Santorini, and partly the fibrous connective tissue, by which the cartilaginous meatus is fastened to the osseous portion. They then ramify in the lining membrane of the external meatus, forming a fine capillary network on the perichondrium and around the glands of the hair-sacs and the sebaceous glands. A considerable vascular bundle extends along the superior wall of the meatus towards the upper margin of the membrana tympani, where it passes on to the membrane with a sheath of connective tissue, as will be described later on, extending along the posterior margin of the handle of the malleus to its inferior extremity.

The veins of the auricle and of the external meatus show numerous varieties in regard to their junction with the larger venous trunks on the lateral portions of the head. The *venæ auric. ant. post.* and *profund.* unite chiefly with the *vena jugularis externa* and the *mastoidea;* not unfrequently, however, a portion of the veins from the external ear join the *vena temporalis* and the *vena maxillaris interna.*

On the whole, there is very little known regarding the lymphatic vessels of the external meatus. It is, however, probable that they are very often connected with the lymphatic glands lying upon the parotid under the meatus, as there is frequently a swelling of the lateral cervical glands accompanying inflammatory affections in the meatus.

The nerves of the auricle and of the meatus come from the *nervus facialis*, which sends the *n. auric. post. profundus* to the posterior surface of the auricle; from the *trigeminus*, the third branch of which supplies the skin of the auricle and of the external meatus with some twigs of the *n. auriculo-temporalis;* from the *plexus cervicalis*, which takes part through the *n. auricularis magnus* in the supply of the external ear; from the *n. vagus*, which assists in the supply of the external meatus through the *ramus auricularis vagi*, discovered by Arnold, coming from the *ganglion jugulare*, entering the posterior wall of the meatus as a considerable branch, and supplying the lining

membrane of the meatus. A large nervous branch extends from the superior wall of the meatus to the membrana tympani.

e. Size and Direction of the External Meatus.

The capacity of the external meatus in the adult is subject to many individual variations. The cartilaginous portion is often so wide that the little finger can be inserted without trouble as far as the osseous portion; in others, again, the lumen is found narrowed to the diameter of a goose-quill. The lumen of the cartilaginous meatus, which, inside the orifice of the external ear, is 5 to 7 mm. in diameter, gradually widens as it passes inward, especially posteriorly, to 9 to 11 mm. It shows again a moderate narrowing towards the place of union with the osseous portion (7-9 mm.), but suddenly enlarges within the osseous portion. In childhood the cartilaginous meatus is narrower than in the adult, and therefore examinations and operations are generally more difficult. On the other hand, in old persons a slit-like closure of the orifice of the external meatus often takes place in consequence of atrophy and shrinking of the cartilage.

The capacity of the osseous meatus also presents many individual varieties. Its calibre gradually becomes less in passing from its external orifice (Fig. 9) inwards, is least at the margin of the inner third of the osseous portion (*isthmus*), and again increases considerably in size from this point towards the insertion of the membrana tympani. In the section the lumen of the meatus is somewhat rounded in appearance towards the outside, and in the deeper portion till above the isthmus more elliptic in form (Fig. 12), the diameter of the ellipse not being perpendicular, but a little inclined forwards. It follows from this, that the isthmus is in that part of the meatus where the anterior and inferior walls display the greatest convexity towards the lumen. As this is the place where foreign bodies become wedged in, and where, if they penetrate deeper still, the greatest obstacle is offered to their extraction, it is important to know that the distance of the isthmus (front) from the anterior margin of the membrana tympani amounts to 7-8 mm.; from the posterior margin, however (on the posterior wall), only 1-2 mm. In case of attempts at extraction the instrument can, therefore, be inserted along the superior and posterior walls only with great caution, so as to avoid injuring the membrana tympani (v. Tröltsch). The transverse diameter of the osseous meatus amounts at the isthmus to 6 mm.; at the interior and exterior extremities to 9-10 mm.

FIG. 12.—SECTION OF THE EXTERNAL MEATUS.

a, Lumen of the meatus; *b*, Anterior wall; *c*, Mastoid cells.

According to Bezold, the longer diameter at the commencement of the osseous meatus is 8·7 mm., the shorter 6·1 mm.; at the inner end, or rather

on a section through the outer pole of the membrana tympani these diameters are 8·1 and 4·6 mm. respectively.

The lengths of the different walls from the external orifice of the ear to the insertion of the membrana tympani are unequal. V. Tröltsch in his measurements assumes as the exterior boundary of the meatus a sagittal plane, passing through the posterior margin of the orifice, and according to him the length of the superior wall amounts to 21 mm., that of the inferior to 26 mm., that of the anterior to 27 mm., and that of the posterior wall to 22 mm. On an average the length of the whole meatus is 24 mm., of which more than one-third is taken up by the cartilaginous portion.

The meatus in its course from the external orifice to the mem-

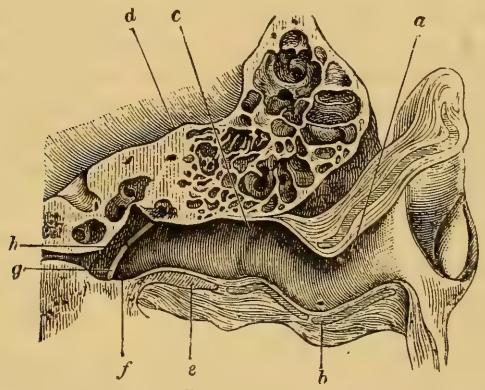

FIG. 13.—HORIZONTAL SECTION OF THE EXTERNAL MEATUS.

a, Concha ; *b*, Tragus ; *c*, Place of attachment of the cartilaginous portion ; *d*, Mastoid process ; *e*, Anterior wall of the meatus ; *f*, Sin. meat. audit. extern. ; *g*, Membrana tympani ; *h*, Tympanic cavity (left ear).

brana tympani displays several curves, which deserve full consideration in regard to examinations of the membrana tympani, as well as in respect to operations in the meatus. Although the whole meatus appears spirally twisted about its axis (Fig. 14) it may on the whole be assumed that the cartilaginous portion in passing inwards turns backwards and upwards, the osseous portion forwards and downwards.

The longitudinal axes of the two portions of the meatus therefore form an open angle forwards and downwards, and as the meatus from the place of union of the two portions slopes both outwards and inwards, the inferior part of the external orifice and of the membrana tympani must lie lower than the other parts of the meatus.

According to the observations of Laufel and Symington, in the new-born the lumen of the meatus is wanting in the inner segment, as the membrana

tympani lies with its whole surface upon the inferior wall. This condition is favoured on the one hand by the outward and upward direction of the meatus, and on the other, as v. Tröltsch rightly observes, by the strongly developed layers of epidermis on the membrana tympani and the meatus.

II. THE MIDDLE EAR.

The middle ear, the most important part of the ear from a pathological point of view, is divided into—(1) The tympanic cavity; (2) the Eustachian tube; and (3) the mastoid process.

A. The Tympanic Cavity.

The tympanic cavity is an irregular, three-sided, prismatic (Henle) cavity (Fig. 9, *f*), compressed from without inwards, in which the diameters from above downwards, and from before backwards, are greater than from without inwards. Although the walls forming the cavity are in some places not sharply defined, it is necessary for a clear representation of the anatomical facts to describe these different parts as walls of the tympanic cavity. We will therefore commence with a description of its exterior wall, and the first subject for our attention will be the membrana tympani, which forms the greater part of this wall.

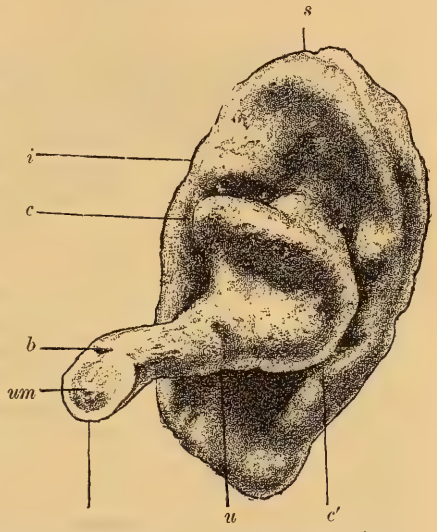

Fig. 14.—Corrosion Cast of the Auricle and of the External Auditory Canal. (After Bezold.)

s, Fossa scaphoidea; *i*, Fossa intercruralis; *c*, Upper, *c'*, Lower portion of the concha; *u*, Second bend of the external meatus; *t*, Border of the tympanic membrane; *um*, Umbo; *b*, Depression of the membr. Shrapnelli, and of the proc. brevis.

The names of the walls of the tympanic cavity—exterior, interior, superior, and inferior—are not in keeping with their actual positions, as the direction of the cavity from above downwards is not perpendicular, but extends in an oblique direction downwards and inwards (towards the middle line). If we adhere to the old names it is necessary, owing to the important practical significance of these relations, never to lose sight of the fact, that in the normal position of the head the exterior wall becomes an exterior inferior by its inclination; the interior wall, which completely roofs the exterior wall, an interior superior; the inferior wall an inferior interior; and the superior wall a superior exterior.

a. The Membrana Tympani.

The membrana tympani appears at the inner extremity of the osseous meatus as an irregularly oval membrane, concave outwardly, and placed obliquely to the longitudinal axis of the meatus.

The margin of the membrane is embedded in a groove-like sulcus (*sulcus tympanicus*), situated at the inner end of the meatus. This sulcus belongs to the tympanic ring (Fig. 6) already mentioned, and exists on the perfect temporal bone (Fig. 15) only to the extent of the part taken by that ring in the formation of that bone. In front and above, however, at the so-called Rivinian segment (Fig. 15, *b*), the sulcus is wanting altogether, and the pars flaccida of the membrana tympani is here united partly to the grooveless margo tympanicus and partly to the ligam. malleus externus.

Form of the Membrana Tympani.—The form of the membrana tympani varies between the elliptic, the irregularly oval, and the heart-shaped forms. Especially at two places the membrane is bulged out towards the periphery, viz., behind and above, into a large segment of a circle (Fig. 15, *c*), and also as the Rivinian segment at the anterior superior pole (Figs. 15, *b*, 16, *c*, and 17, *s*) of the membrane above the short process of the malleus. This segment is marked off from the remaining periphery of the sulcus of the membrane by two more or less sharply-defined angular projections (Figs. 15 and 16), the distance of which from each other at the base amounts to 2½-3 mm., the height of the rounded protuberance being about 2mm. (Prussak).

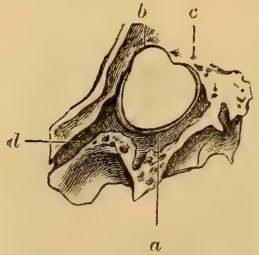

FIG. 15.—SULCUS OF THE MEMBRANA TYMPANI AT THE INNER EXTREMITY OF THE MEATUS.

a, Sulcus; *b*, Anterior superior grooveless bulging out of the periphery of the membrana tympani (margo tympanicus) or Rivinian segment; *c*, Osseous wall of the tympanic cavity behind the membrana tympani; *d*, Exterior wall of the cavity extending into the Eustachian tube. (Right ear.)

Size of the Membrana Tympani.—The size of the membrana tympani presents more or less noteworthy deviations in different individuals. From numerous measurements taken by me, it appears that the greatest longitudinal diameter from the point of the *spina tympanica post.* to the lowest point of the inferior margin of the membrane amounts to 9½-10 mm., the greatest transverse diameter from the anterior to the posterior margin measures 8½-9 mm. Bezold's measurements, made on specimens prepared by corrosion, give the average of the two diameters as 9·2 and 8·5 mm.; the thickness of the membrane between the handle and the tendinous ring, according to Henle, amounts to 0·10 mm.

The Inclination of the Membrana Tympani.—The inclination of the membrana tympani depends in the adult on the inclination of the sulcus tympanicus to the axis of the meatus. The inclination of the plane of the sulcus will of course be greater the farther the anterior and inferior walls of the meatus reach inwards beyond the posterior and superior walls (Figs. 9

and 10). Bezold's measurement on corrosion preparations gives the average angle as 27-35°. V. Tröltsch places the angle which the plane of the membrane forms with the superior wall of the meatus at an average of 140°.

Dr. J. Pollak maintains that there is no perceptible difference between the inclination of the membrane in the new-born infant and in the adult.

Curvature of the Membrana Tympani.—In the above-described oblique position the membrana tympani is not stretched out as a plane surface, but is curved in such a manner that it turns its concavity outwards, and its convexity towards the interior of the tympanic cavity (Fig. 9, *e*). The deepest part of the curvature, the so-called *umbo*, corresponds with the inferior extremity of the handle of the malleus, which is enclosed in the layers of the membrana tympani. By the traction of this handle inwards the

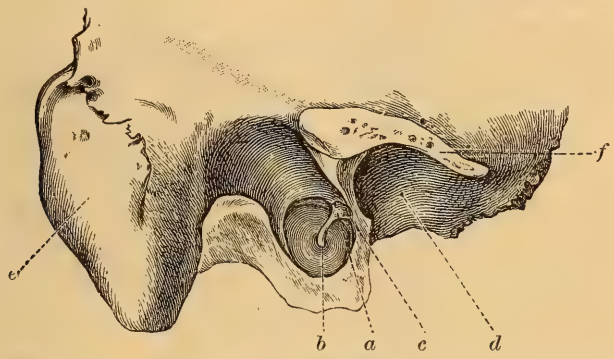

FIG. 16.—EXTERNAL SURFACE OF THE MEMBRANA TYMPANI (NATURAL SIZE).
a, Short process of the malleus; *b*, Inferior extremity of the handle of the malleus (umbo); *c*, Membrana flaccida Shrapnelli; *d*, Cavitas glenoidalis; *e*, Mastoid process; *f*, Section of the zygomatic process. (Right ear.)

membrane appears hollowed out in a funnel-shaped manner. The interior convexity is common to the membrana tympani as a whole, but on closer observation it is seen that the anterior and inferior portions of the membrane, extending from the umbo towards the periphery, show a slight curvature with external convexity (Fig. 9). This partial bulging out, as opposed to the curvature of the membrane, is due partly to the drawing inwards of the membrane by the traction of the handle of the malleus, partly to the action of the circular fibres upon the radiating fibrous layers (Helmholtz). That portion of the membrane which is situated behind the handle of the malleus appears more relaxed, and shows a less regular curvature than its anterior and inferior portions.

The shaft-like handle of the malleus (Figs. 16 and 17), intimately united with the layers of the membrane, and strongly inclined inwards, extends in an oblique direction from the front and above, backwards and downwards, and ends at the umbo in a flattened extremity.

The handle of the malleus, which divides the membrana tympani into two unequal portions, a lesser anterior one (Fig. 17, *v*) and a larger posterior one (*h*), extends forwards and upwards to the short process of the same bone (Fig. 16, *a*). This short process is recognisable on the membrane by a strongly-

marked, partially-pointed projection at its anterior superior pole. Before and behind this pole are two folds, due to the partial bulging forwards of the membrane. These folds are of a more or less decided character, and when the membrane is abnormally concave they often have the appearance of gray, tendinous bands. We will show their important diagnostic significance in describing the pathological conditions of the membrana tympani.

At the anterior superior pole of the membrana tympani, near the folds and above them, there are also to be found two short, tightly-stretched striæ, which take origin in the corners of the segment of Rivini, and extend, converging towards each other, to the point of the short process (Fig. 17, *s*, *s*). These striæ, which were first described by Prussak, and which in examinations made during life are often visible as marked white lines, appear somewhat sunken in dried preparations.* The portion of the membrane (Fig. 17, *ms*) which is bounded by these striæ and the grooveless fissure, is generally called the *membrana flaccida Shrapnelli*. It is much thinner and less tense than the other parts of the membrana tympani, and it appears therefore above the short process as a small, pit-like depression, and forms the outer wall of a small space, communicating with the tympanic cavity, which is called Prussak's cavity.

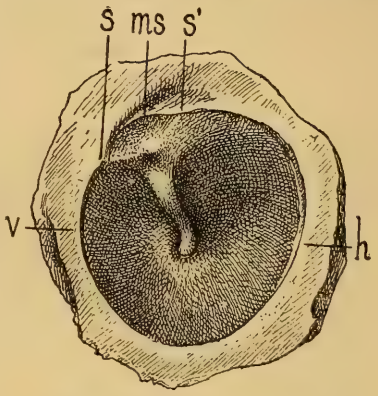

FIG. 17.—OUTER SURFACE OF THE LEFT TYMPANIC MEMBRANE OF AN ADULT, ENLARGED 3½ TIMES.

v, Segment of the tympanic membrane lying in front of the handle of the malleus; *h*, Posterior segment of the tympanic membrane; *s*, *s'*, Prussak's striæ, passing from the short process of the malleus to the spina tymp. post. et minor; *ms*, Membrana Shrapnelli.

As regards the interior surface of the membrana tympani, the rounded head of the malleus, and the incus connected with it by a joint, come first into view above the membrane (Fig. 18, *a*, *d*, *g*). Below the head of the malleus is the neck, from which proceeds downwards and backwards the handle (Figs. 17 and 18). The latter is closely connected with the membrane; indeed the bulk of the handle bulges out over the surface of the membrane, so that it appears as if it were lying on it. On separating the incus from the malleus, there will be found a fold on the posterior segment of the membrane, which has been described by v. Tröltsch. It begins from a slightly rounded ridge of bone lying in the sulcus, and from the posterior superior part of the angular projection of the annulus tympanicus projects forwards, till it fastens itself to the posterior surface of the handle of the malleus. Standing out from the membrana tympani with a free inferior margin, this fold forms with the surface of the membrane the posterior pouch of the membrana tympani (v. Tröltsch, Fig. 18, *f*), the relations of which are shown in the accompany-

* Superior striæ for the attachment of the membrana tympani (Helmholtz).

ing cut (Fig. 19). The smaller anterior pouch is enclosed by an osseous projection from the neck of the malleus, the ligamentous and osseous remains of the long process of the malleus; by the chorda tympani, the *arter. tymp. inf.* and the lining membrane. The superior boundary of the anterior pouch is formed by the gray stria extending from the short process to the anterior angular projection of the annulus tympanicus (Prussak). The constant occurrence of the aperture at the superior anterior pole of the membrana tympani, described by Rivinus (1689), and corroborated by Bochdalek (*Prager Vierteljahrschrift*, 1866), is in nowise proved.

Microscopic Anatomy of the Membrana Tympani.—As was known to older investigators, the membrana tympani consists essentially of three

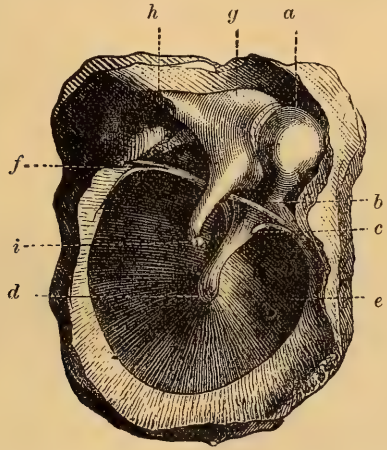

FIG. 18.—INTERNAL SURFACE OF THE LEFT MEMBRANA TYMPANI (ENLARGED).

a, Head of the malleus; *b*, Neck of the malleus; *c*, Tendon of the m. tensor tympani and anterior fold of the membrana tympani; *d*, Inferior extremity of the handle of the malleus; *e*, Anterior portion of the membrana tympani; *f*, Posterior fold of the membrana tympani and chorda tympani; *g*, Incus; *h*, Short process of the incus; *i*, Long process of the incus.

principal layers, a middle fibrous layer, the *lamina propria*, an external dermic layer, and an internal layer of mucous membrane, the two last named being the coverings which the lamina propria receives from the lining membrane of the external meatus and of the tympanic cavity. The dermic layer may be easily detached from the fibrous, but the internal layer is so closely connected with the fibrous, that it is not possible to separate them.

The dermic layer consists of several strata of pavement epithelium with a Malpighian mucous layer, but possesses only a very slight stratum of connective tissue, which appears to furnish a constant covering for the vessels and nerves of this layer.

We have already mentioned that, especially in the new-born infant, a strongly developed cutaneous band extends from the superior wall of the external meatus to the membrana tympani and behind the handle of the malleus, so that between the handle and the cutaneous band there is left a

triangular transparent space, directed with its apex towards the extremity of the handle; with this cutaneous band, consisting of connective tissue and elastic fibres (Prussak's descending fibres), there also extend vessels and nerves from the meatus to the membrana tympani. At the inferior and widened extremity of the handle of the malleus, the ligamentous fibres of this bundle radiate towards the periphery, and partly unite with the fibres of the *substantia propria*.

The middle fibrous layer consists of two separable lamellæ, an external radiating layer, and an internal circular layer. The pale, filamentous and delicately defined fibres of these two layers form a tissue, which, according to

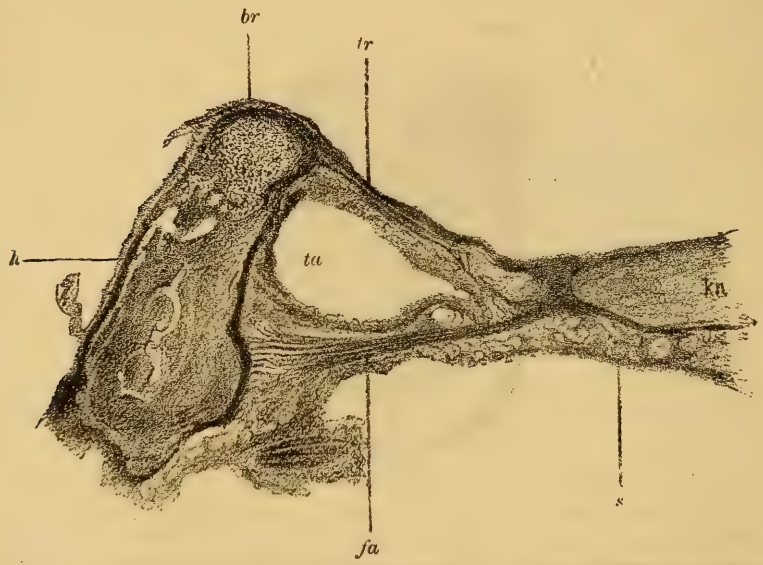

FIG. 19.—SECTION THROUGH THE MALLEUS AND THE POSTERIOR TYMPANIC POUCH AT THE LEVEL OF THE SHORT PROCESS OF THE MALLEUS.

h, Malleus; *br*, Cartilaginous portion of its short process; *tr*, Posterior portion of the tympanic membrane; *fa*, Posterior fold of the tympanic membrane; *ta*, Posterior pouch of Von Tröltsch; *s*, Mucous lining of the tympanic cavity.

Gerlach, is, so to say, midway between the usual fibrillated and the homogeneous connective tissue of Reichert. According to the embryological investigations of Draispul the lamina propria of the membrana tympani is a direct continuation of the periosteum of the annulus tympanicus. The outer radiating fibres partially cross, and are principally at the lower part, and attached to the enlarged end of the handle of the malleus (Fig. 20, *v*). In the upper portion are only a few fine fibres at the anterior border of the handle of the malleus. They become at the same time more dense towards the centre, partly because they multiply by splitting of the fibres (Gerlach), and partly because they thicken at the umbo by accumulation in the limited space (v. Tröltsch).

The inner lamella consists of fibres which, from their circular arrangement,

cross the direction of the radiating fibres. At the margin it is closely connected with the origin of the radiating layer; both layers, however, are easily separable from each other from this point to the handle of the malleus. The fibres of the circular layer, which can be traced to the tendinous ring, are wanting on the external margin of the membrana tympani. They collect themselves and are most dense within the tendinous ring, which consists of compact fibrous connective tissue, while they become more sparse towards the centre. The circular fibres go more to the external surface of the handle of the malleus above, on account of which the handle appears more prominent on the inner surface. A crossing and amalgamation of the fibres from both sides of the malleus handle appears to take place only at the lower third. This portion of the hammer is most closely united with the membrana tympani, while above a large portion of the external surface of the handle is lying on the membrana tympani, and the connection is less secure. Between the fibres of the two layers, the corpuscles of connective tissue, called Tröltsch's corpuscles after their discoverer, are seen spindle-shaped in the longitudinal sections, and star-like in the transverse. They are very similar to the corpuscles of the cornea, their delicate processes anastomosing with each other, and spreading on either side towards the vascular cutaneous layer and the layer of lining membrane, to draw from them their nutrition. According to v. Tröltsch, the cells of the epithelial surface of the lining membrane are connected by processes with the corpuscles of the membrana tympani; Prussak has confirmed the occurrence of the spindle-shaped fibres in the membrane (organic muscular fibres) described by Everard Home.

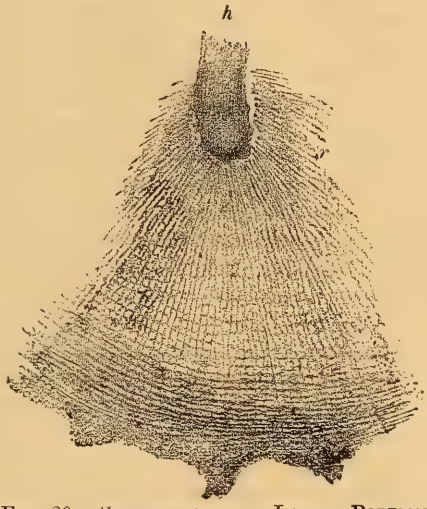

FIG. 20.—SEGMENT OF THE LOWER PORTION OF THE TYMPANIC MEMBRANE.
h, Handle of the malleus; *r*, Layer of radiating fibres; *c*, Layer of circular fibres.

The inner layer, a continuation of the lining membrane of the tympanic cavity, is closely united with the circular fibrous layer, and consists of a very scanty stratum of connective tissue with a covering of non-ciliated pavement epithelium. Gerlach has found on the lining membrane of the membrana tympani, in not inconsiderable quantities, projections like the villi of the intestine, covered with a layer of flattened cells, and they contain one or more capillary clusters. They occur in greatest numbers on the membrana tympani of the new-born infant.

The fibres of the substantia propria are lacking in the membrana Shrapnelli, and it consists of delicate interlacing fibres of connective tissue covered externally by a thin cuticular layer, and internally by the mucosa of the

tympanum. It is penetrated by bloodvessels which are inconstant in their course and anastomosis.

The membrana tympani possesses two vascular networks, separated by the substantia propria, and anastomosing with each other at the periphery, the outer one belonging to the connective tissue of the cutis, the inner to the mucous membrane.

The vascular network of the cutis comes from the arteria auricularis profunda, which sends a branch to the centre of the membrana tympani. This branch lies between two venous branches, which form a plexus here and there, and descends to the umbo from the superior posterior wall of the meatus, behind the handle of the malleus. These vessels do not lie immediately behind the handle, but at some distance from it, in such a way that between them and the bone a portion of the membrana tympani is visible, its point directed downwards. At the centre of the membrane the arteries as well as the veins communicate by numerous radiating branches with a vascular zone, situated at the periphery of the membrane, and through this also with the vessels of the tympanic cavity (Moos, *Archiv. f. Augen. und Ohrenheilk.*, vol. vii.). According to Moos, anastomosing bloodvessels perforate the membrana tympani in the region of the hammer and at other places. According to the investigations of Prussak, the veins are in greatest numbers at the handle of the malleus, as well as at the periphery. The arterial branches which run along the handle of the malleus, partly enter at once into the venous plexus in the neighbourhood, and partly pass across the membrana tympani to the marginal venous zone. Burnett found vascular loops always present on the membrana tympani of the ox, the cat, and the goat.

The veins of the cutaneous layer of the membrana tympani are connected partly with the veins in the external meatus, partly, on the periphery of the membrana tympani, with the vessels in the tympanic cavity through apertures sometimes of considerable size.

The vascular network on the surface of the lining membrane springs from the vessels of the tympanic cavity, and presents a rather closely meshed capillary system, developed from an artery which runs parallel to the handle of the malleus, on the inner side of the membrana tympani (Moos). The lymphatic vessels of the membrane, according to Kessel (*Handbuch der Lehre von den Geweben*, 1870), are, like the bloodvessels, arranged in three layers anastomosing with each other. If the epithelium of the lining membrane be brushed off, with a low microscopic power, a fibrous framework (designated by Gruber dentritic formation) will be found lying upon the substantia propria, which is often spread over the whole membrane, but is especially developed on that part situated behind the handle of the malleus.

From the membranous expansion of this fibrous framework, which is interrupted here and there (Fig. 21, *a*) by large and small interspaces, there radiate towards the handle of the malleus, as well as towards the peripheral tendinous ring, processes which form curves of different sizes. These processes strike deep and amalgamate with the fibres of the substantia propria. According to my own investigation a similar formation is to be found in the mucous membrane of the cavum tympani, and consequently it cannot be considered a structural peculiarity of the membrana tympani.

The nerves of the membrana tympani, which, according to Arnold, spring from the *nervus temporalis superficialis* of the *trigeminus*, but which were minutely examined for the first time by v. Tröltsch, are spread out on the external layer, parallel with the vessels, in the form of three or four very delicate, ill-defined branches, the terminations of which are, so far, unknown. Kessel says that he has sometimes observed round the vessels and between their meshes a large nervous plexus and gangliar swellings on the nerve-fibres. In the *rete Malpighii* there is a second plexus supplied with multipolar cells. The nerve-fibres of the cutis, while regularly dividing dichotomously, penetrate the substantia propria and come into connection with the nervous plexus of the lining membrane. Gerlach observed delicate non-medullated

FIG 21.—FIBROUS FRAMEWORK OF THE POSTERIOR SEGMENT OF THE INTERIOR SURFACE OF THE MEMBRANA TYMPANI IN THE ADULT.

a, Great interspace in the framework; *b*, Small interspace, through which a thin process passes; *c*, Arch formed by radiating processes.

nerve-fibres in the covering of the lining membrane. Forming the external wall of the cavum tympani, besides the membrana tympani, is a margin of bone; bordering on it and above is a smooth cup-shaped niche, which serves to hold the bodies of the hammer and incus (*Logette des Osselets*, Gellé).

b. Superior Wall of the Tympanic Cavity.

The superior wall, or roof, of the tympanic cavity is formed by an osseous plate, continuous with the superior surface of the pyramid. This plate extends beyond the boundaries of the tympanic cavity, forming not only a part of the superior lamella of the osseous meatus, but also the upper wall of the mastoid

antrum, and the roof of the canal for the tensor tympani, and of the osseous portion of the Eustachian tube.

In the ear of the infant, on the upper wall of the tympanic cavity will be found a suture (*sutura petroso-squamosa*), which is formed by the meeting of the roof of the tympanic cavity with the inner lamella of the squamous portion of the temporal bone. Through this suture, in the new-born infant, processes of connective tissue, containing bloodvessels, pass from the dura mater into the tympanic cavity (Wagenhauser). This explains why children suffering from acute tympanitis often exhibit symptoms of meningeal irritation, the hyperæmia in the tympanic cavity spreading by means of these vascular connections to the dura mater.

In the adult this suture is firmly closed, and with the exception of a few traces, the connective tissue processes have disappeared. It is indicated on the macerated bone by a jagged furrow, and is not situated above the tympanic cavity, but for the most part above the osseous meatus. The projecting curved process of bone on the under surface of the tegmen (*Crista transversa tymp.*, Bezold) serves for the attachment of a fold of mucous membrane, which is connected with the *tensor* tendon.

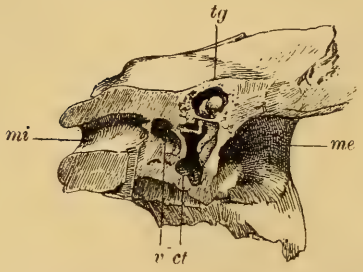

FIG. 22.—FRONTAL SECTION THROUGH THE EXTERNAL MEATUS, TYMPANUM AND THE LABYRINTH OF AN ADULT.

me, Meat. audit. extern. ; *ct*, Cavum tymp. with the tympanic membrane, the ossicular chain and the tensor tendon ; *tg*, Tegmen tymp. ; *v*, Vestibule ; *mi*, meat. audit. intern. After a preparation in my collection. The annulus tymp. and the tympanic membrane are preserved intact. (Left ear.)

The thickness of the superior wall of the tympanic cavity above the head of the malleus amounts to 5-6 mm. Sometimes the roof is formed by a thin osseous plate, but often it is thickened by a cellular osseous substance ; it is, however, much thinner than the superior wall of the meatus. The space due to the difference in thickness of the superior wall of the osseous meatus and the superior wall of the tympanic cavity, and in which the head of the malleus and the body of the incus are situated, is called the upper space of the tympanic cavity (attic of the tympanum, cavum epitympanium).

An examination of a large number of macerated crania will often show that the delicate transparent osseous plate of the roof of the tympanic cavity is defective, being pierced by one or more irregular apertures, and that sometimes a great part of the roof of the tympanic cavity may be wanting.*

c. Inferior Wall of the Tympanic Cavity.

The inferior wall of the tympanic cavity is narrower than the superior. It is limited behind by the posterior wall, and before by that gentle elevation of the inferior wall towards the anterior, which is situated below the ostium

* This anomaly, which is designated by Hyrtl as spontaneous dehiscence of the tegmen tympani, is probably due to arrested development.

tympanicum tubæ. Its surface usually presents ridges and hollows,* but is often smooth and bulged forward towards the tympanic cavity by the adjoining fossa jugularis. Its thickness varies in the same manner as that of the superior wall.

The proximity of the inferior wall of the tympanic cavity to the fossa jugularis is worthy of remark, because a fatal phlebitis with thrombosis in the bulbus venæ jugularis is often brought about by caries of this wall.

d. Posterior Wall of the Tympanic Cavity.

The height of the posterior wall, rising abruptly from the floor of the tympanic cavity (Fig. 23), amounts to several millimetres. Above it there is a great triangular aperture, which is the means of communication between

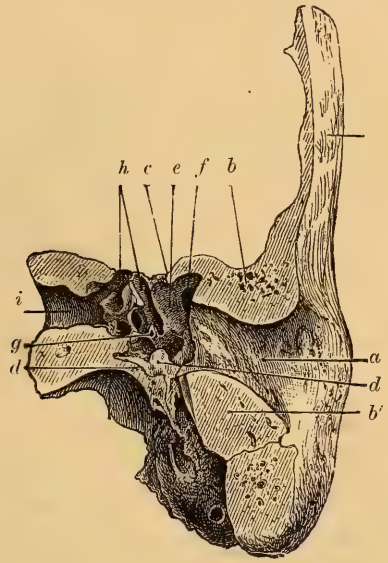

FIG. 23.—VIEW OF THE POSTERIOR WALL OF THE TYMPANIC CAVITY.

a, Meatus ; *b*, *b'*, Superior and inferior walls of the meatus ; *c*, Superior wall of the tympanic cavity ; *d*, Protuberance underneath the eminentia stapedii, caused by the superior extremity of the styloid process ; *e*, Posterior wall ; *f*, Entrance into the mastoid process ; *g*, Eminentia stapedii ; *h*, Canalis Fallopiæ ; *i*, Interior meatus.

the tympanic cavity and the mastoid process. In the inferior angle of this aperture a saddle-shaped notch will be found, in which rests the short process of the incus. From the surface of the posterior wall there arises a small osseous projection, directed forwards, on the pointed extremity of which a delicate and rounded aperture is visible. This is the *eminentia pyramidalis* (*g*), which is connected with the Fallopian canal by one or more

* In this wall also dehiscences have been observed similar to those in the superio wall (Friedlowsky).

fissures, and which encloses the muscle of the stapes, the tendon of which passes through the rounded aperture to the capitulum of the stapes.

Below the eminentia stapedii very often a more or less pronounced irregular protuberance (*d*) will be seen, which, as I was the first to prove,* is caused by the bulging out of the superior extremity of the styloid process (*protuberantia styloidea.*) This process, which according to Gradenigo is composed of two parts, an upper and a lower, and is stated by Reichert to originate from the second branchial arch, is mostly quite cartilaginous after birth, and ossifies only in the course of the first year. As first described by me, the shape of its superior portion in the new-born infant (Fig. 24) is that of a club, the upper knobby extremity of which is located underneath the

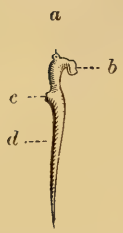

FIG. 24.—STYLOID PROCESS IN THE NEW-BORN INFANT.

a, Superior extremity pointed towards the posterior wall of the tympanic cavity; *b*, Club-like extremity pointing backwards; *c*, Short cartilaginous process; *d*, Inferior extremity.

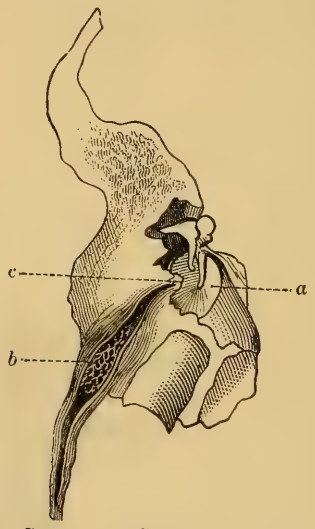

FIG. 25.—SECTION OF STYLOID PROCESS IN THE ADULT.

a, Membrana tympani; *b*, Medullary cavity of the styloid process; *c*, Its superior extremity with the protuberance on the posterior wall of the tympanic cavity.

eminentia stapedii. The rounded extremity of the club (*b*) is pointed backwards, and rests in a cup-shaped depression of the mastoid antrum, directed forwards. This small cavity (½mm. in diameter) on the anterior portion of the mastoid cells I have found at different times in the macerated temporal bones of new-born infants, the superior extremity of the styloid process not yet having been ossified or united to the mastoid process on its posterior boundary. So far as I know, this small, cup-shaped cavity of the mastoid process in the new-born infant was first observed by me.†

The ossification of the styloid process commences at its superior extremity,

* *Arch. f. Ohrenheilk.*, vol. x.

† Politzer, *The Anatomical and Histological Dissections of the Human Ear*, p. 49, Fig. 52, *c*.

often before birth. By carefully opening the sheath of this process in the macerated temporal bone of the new-born infant, it will therefore often be found that its uppermost ossified portion is firmly united with the bone at the place where the above small cavity is situated.

The projection on the superior extremity of the styloid process, which is directed forwards, is adjacent to the posterior wall of the tympanum, and often presses it forwards in the shape of a rounded swelling against the lumen of the tympanic cavity.

In the adult I have also succeeded in tracing the styloid process to its uppermost extremity. In carefully made sections (Fig. 25), I found the cortical substance of the styloid process closely united with the surrounding osseous tissue; and I could trace the medullary space (*b*) to its superior extremity, bordering on the posterior wall of the tympanic cavity.

e. Anterior Wall of the Tympanic Cavity.

The anterior wall of the tympanic cavity is formed only by the short, ridgy, and oblique plane which rises at the anterior boundary of the inferior wall (Fig. 26). Above this plane, on the same level as the entrance into the mastoid process, a large irregular aperture, the ostium tympanicum tubæ, leads into the osseous Eustachian tube, which lies immediately below the canal for the tensor tympani. The ridgy, sometimes dehiscent, anterior wall of the tympanic cavity is closely applied to the carotid canal. According to a number of observations, a sudden fatal hæmorrhage may occur from caries of this wall opening the carotid artery. The walls of the carotid artery do not, however, lie close to the osseous canal, as they are surrounded by a venous sinus, which is connected with the sinus cavernosus, as was first proved by Rektorzik.

f. Inner Wall of the Tympanic Cavity.

The relations of the inner wall, or labyrinth wall, of the tympanic cavity (Fig. 26) are more complicated. In it there are two fenestræ, closed by elastic plates, and leading to the labyrinth, the great importance of which in the physiology of the ear we shall see later on. The oval or bean-shaped fenestra (*a*), which leads to the vestibule of the labyrinth, and is situated at the extremity of a deep niche, receives the foot-plate of the stapes. This niche is called the pelvis ovalis, and, as we shall see, is very often the seat of pathological changes. The greatest diameter of the aperture (3·5-4 mm.) extends from before backwards and downwards; the height from without inwards and downwards is $1\frac{1}{2}$ to 2 mm. The plane of the fenestra ovalis is therefore strongly inclined towards the axis of the ear. The upper border of the fenestra ovalis is strongly convex, while the lower is slightly concave. The anterior rounded end is much wider than the posterior, at which the upper and lower borders meet with a sharp bend.

Below the fenestra ovalis (at a distance of 3-4 mm.), the entrance to the niche of the fenestra rotunda (Fig. 26, *b*) will be seen, directed backwards. In an obliquely-placed groove at its base, a small, delicate membrane (*membrana fenestra rotunda sive memb. tymp. secundaria Scarpæ*), somewhat

concave towards the membrana tympani, is stretched out, which shuts out the cochlear canal from the tympanum. The height varies from 1·6 to 3 mm., the width from 1 to 3 mm. Between the niche and the eminentia pyramidalis is a depression in the wall, varying in size in different individuals (*Sinus tymp.*, Steinbrügge).

Between and a little in front of the two fenestræ, the wall of the tympanum is strongly bulged out towards the cavity; this is due to the projection of the first whorl of the cochlea, and is called the promontory. Vertically above it, in an open or covered groove, extends Jacobson's nerve, which connects the jugular ganglion with the n. petrosus superf. minor. A number of inconstant winding furrows show the course of the nerve branches of the plexus tympanicus in the mucous membrane covering the promontory.

Above and slightly behind the fenestra ovalis there is seen a portion of the

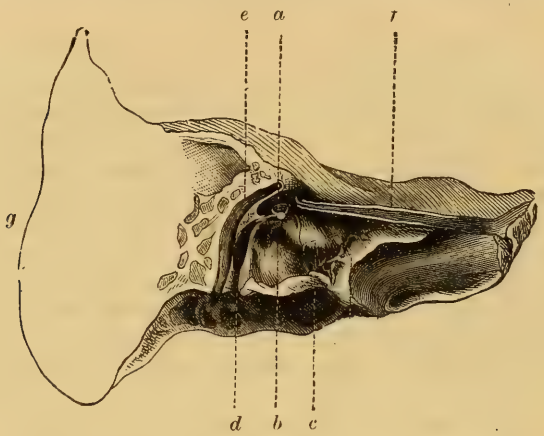

FIG. 26.—INNER WALL OF THE TYMPANIC CAVITY.

a, Fenestra ovalis with the stapes; *b*, Fenestra rotunda; *c*, Promontory; *d*, Musc. stapedius; *e*, Canalis Fallopiæ; *f*, Canal for the tensor tympani; *g*, Mastoid process.

Fallopian canal, containing the facial nerve. The Fallopian canal commences in the internal meatus, above the place where the auditory nerve enters the labyrinth, passes then into the substance of the petrous bone above the vestibule towards the outer side, and, arrived at the inner wall of the tympanic cavity, forms a knee-like bend (Fig. 26), from which the canal continues backwards along the inner wall of the tympanic cavity above the fenestra ovalis, and extends farther along the boundary between the posterior and the interior walls of the tympanum, with an abrupt bend downwards to the stylo-mastoid foramen.

On the portion of the Fallopian canal extending above the fenestra ovalis, there is an elevation projecting backwards towards the tympanic cavity; this is the wall of the horizontal semicircular canal.

At the anterior portion the promontory becomes flatter, and at the same time narrower, as it is confined between the anterior wall, rising obliquely towards the ostium tympanicum, and the canal for the tensor tympani. This

muscular canal commences at the anterior portion of the temporal bone in the triangular segment, which is formed by the point of the pyramid and the anterior margin of the squamous portion. It lies (Fig. 26, *f*) above the osseous portion of the Eustachian tube, from which it is usually incompletely, but often completely, separated by a thin, osseous lamella. The canal in the tympanic cavity lies on the border between the interior and superior walls, and at the level of the middle portion of the Fallopian canal, in front of and

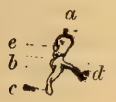

FIG. 27.—MALLEUS.

a, Head; *b*, Neck; *c*, Handle; *d*, Long process; *e*, Articular surface.

FIG. 28.—INCUS.

a, Body; *b*, Short process; *c*, Long process; *d*, Articular surface; *e*, Inferior toothed process.

FIG. 29.—STAPES.

a, Head; *b*, Crus; *c*, Foot-plate.

above the fenestra ovalis, ending in a spoon-shaped process, which is pointed outwards (*proc. cochlearis*), and above which the tendon of the tensor tympani passes across the tympanic cavity to the handle of the malleus (Fig. 30).

g. Ossicula.

The ossicula form an articulated chain, which extends from the membrana tympani (Fig. 30) through the tympanic cavity to the fenestra ovalis. They serve for the conduction of the waves of sound from the membrana tympani to the labyrinth. On the first of these, THE MALLEUS (Fig. 27), which is club-shaped, may be observed the oval head (*a*) with its articular surface directed backwards (*e*), the constricted neck (*b*), the pointed handle connected with the membrana tympani (*c*), the long process inserted into the Glaserian fissure (*d*), and the short process directed towards the external meatus (Fig. 30, *o*). THE INCUS (Fig. 28), the body of which (*a*) resembles the crown of a molar tooth, on the anterior surface of which is the articulation with the hammer, has two processes, the short (*b*), which points backwards towards the entrance into the mastoid process, and the long (*c*), which, slightly bent in a direction almost parallel with the handle of the malleus, points downwards and backwards. On the long process (*c*) there is the processus lenticularis (*ossiculum lenticulare Sylvii*), which unites the long process of the incus to the capitulum of the stapes. The third ossiculum, THE STAPES (Fig. 29), shows many varieties of form. On its capitulum (*a*) a hollowed articular surface for the reception of the lenticular process will be seen. The two cruræ are arched outwardly, and near their junction with the head are very much diminished in size (collum staped.). The foremost is generally a little shorter than the other. They are inserted near the under surface of the foot-plate, which is convex towards the vestibulum, and corresponds in size to the fenestra ovalis. According to the variation in size of the fenestra, the length of the foot-plate varies from 3-3·5 mm., its breadth

1·5-2 mm. The average weight, as given by Eitelberg, of the hammer is 0,023, the incus 0,25, and the stapes 0,002.

The longitudinal axis of the malleus is not straight, the head being bent to the handle at an obtuse angle. The neck of the malleus extends on the inside to the broad rhomboidal surface of the handle. On the external surface of the neck a ledge, wound in spiral form, will be seen, from which the strong check-band of the malleus extends to the outer wall of the tympanic cavity.

On the border between the neck and handle, and from the foremost angle of the interior rhomboidal surface of the bone, the long process of the malleus commences as a small, flattened, and slightly bent, flexible, osseous lamella, which lies in the Glaserian fissure, and is easily seen only in the new-born

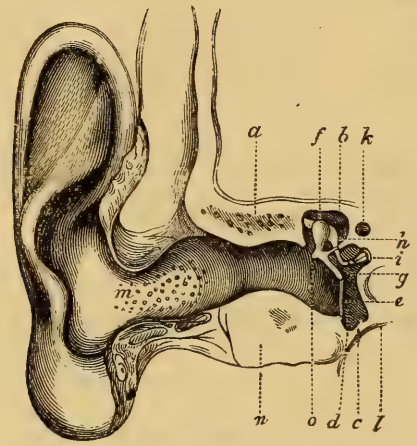

FIG. 30.—VERTICAL SECTION OF THE EXTERNAL MEATUS, MEMBRANA TYMPANI, AND TYMPANIC CAVITY.

a, Cellular spaces in the superior wall of the meatus connected with the middle ear; *b*, Roof of the tympanic cavity; *c*, Inferior wall; *d*, Tympanic cavity; *e*, Membrana tympani; *f*, Head of the malleus; *g*, Handle of the malleus; *h*, Incus; *i*, Stapes; *k*, Fallopian canal; *l*, Fossa jugularis; *m*, Apertures of glands in the external meatus. (Right ear.)

infant. In the adult this process has partially disappeared, and is replaced by a tight ligamentous band, extending from the Glaserian fissure to the malleus.

The handle of the malleus is an angular spiculum of bone. The uppermost part develops outwards into a pointed tubercle of considerable size (short process of the malleus), on the extremity of which is visible, in the macerated preparation, a small rough depression, which is the position of the cartilaginous short process. From the short process the exterior edge of the handle, firmly connected with the membrana tympani, extends backwards and downwards, and merges into its spade-like termination. The internal edge of the handle is developed from the interior rhomboidal surface of the handle. Between the external and internal edges of the handle there are two

surfaces elevated above the level of the membrana tympani, of which the one points forwards and inwards, and the other backwards and outwards.

In the embryonic condition the malleus is cartilaginous, and not only in the new-born infant will the central part be found still unossified (Moos), but even in the adult cartilaginous cells will be observed (Heinrich Müller, *Leitschr. f. Wissenschaft. Zoologie*, 1858). The greater part of the short process consists of hyaline cartilage, and is to be considered as the unossified remnant of the embryonic cartilaginous malleus. The assertion of Gruber, however, that the short process of the malleus has a cartilaginous covering, which is articulated with a corresponding cartilaginous surface on the membrana tympani, covered by an epithelium, has been proved to be erroneous.

h. Articulation of the Ossicula.

1. *Articulation of Malleus and Incus.*—On the posterior surface of the head of the malleus there is an oblong, articular surface, which extends in spiral form from above downwards and inwards to the boundary of the neck.

FIG. 31.—SECTION OF THE ARTICULATION OF MALLEUS AND INCUS.
a, Malleus; *b*, Incus; *c*, Capsular ligament with the wedge-shaped meniscus. (Prepared with hyper-osmic acid.)

It consists of two surfaces, which meet in an almost vertical edge. The under portion of the head of the hammer is described by Helmholtz as the 'cog' of the hammer. Corresponding with this, the incus possesses an articular surface, composed of two parts; its superior portion (Fig. 28, *d*) is directed inwards, its inferior (*e*) outwards. These articular surfaces are covered by a thin layer of hyaline cartilage. The articulation of the two ossicula is effected by a capsular ligament, which is fastened to the somewhat depressed margins of the articular surfaces, and permits of considerable mobility of the bones. From the inner wall of the capsule a fold, first described by Pappenheim (*Specielle Gewebelehre des Gehörorgans*, 1840), and recently confirmed by Rüdinger, projects in the form of a wedge-shaped meniscus into the cavity of the joint (Fig. 31).

The mechanism of the articulation of the malleus and incus is compared by Helmholtz to the check-contrivance inside the key usually supplied with Geneva watches. With the motion of the handle of the malleus inwards, the inferior 'cog' of the malleus (Fig. 27, *e*) catches the inferior cog of the incus

(Fig. 28, *e*), causing the long process of the incus to follow the motion of the handle of the malleus inwards. On the other hand, with the motion of the handle of the malleus outwards, a strong movement of the articular surfaces will follow, the inferior cog of the malleus will recede from that of the incus, the incus will therefore follow only to a slight degree the motion of the malleus outwards.

2. *Articulation of Incus and Stapes.*—This joint is formed by the convex, globular surface of the processus lenticularis of the long process of the incus, and by the correspondingly concave articular surface of the capitulum of the stapes. The mode of union of the articular surfaces, which are covered with hyaline cartilage, does not admit of much separation of the bones from each

FIG. 32.—SECTION THROUGH THE INCUDO-STAPEDIAL ARTICULATION.

a, Terminal piece of the long crus of the incus, and connected with it by fibrous tissue ; *o*, Ossicul. lentic. Sylvii ; *st*, Capitulum stapedis ; *g*, Articular fossa with the meniscus ; *c*, *c'*, Hyaline cartilage covering of the articular surfaces ; *k*, *k'*, Articular capsule ; *m*, Tendon of the musc. stapedis.

other, but allows them to move sideways to a greater extent. The capsular ligament, which unites the articular extremities, is composed of numerous elastic fibres. According to Rüdinger it is also provided with a meniscus.

3. *Stapedio-vestibular Articulation.*—The tissue connecting the margin of the fenestra ovalis with the margin of the foot-plate of the stapes, consists of elastic fibres, which extend in a radiating direction, converging towards the margin of the foot-plate. This ligament, not equally broad at all parts, is composed of a layer of periosteum of the osseous portion bordering the fenestra ovalis, and takes upon itself the functions of the periosteum from the place where the foot-plate of the stapes is situated. As Toynbee and Magnus have already proved, the margin of the foot-plate of the stapes, as well as that of the fenestra ovalis, are covered with a thin layer of carti-

laginous tissue, which, according to Eisell, lines the vestibular surface of the stapes, and encloses in the shape of a heel the margin of the foot-plate. From Gradenigo's investigations the inner portion of the foot-plate to the stapes

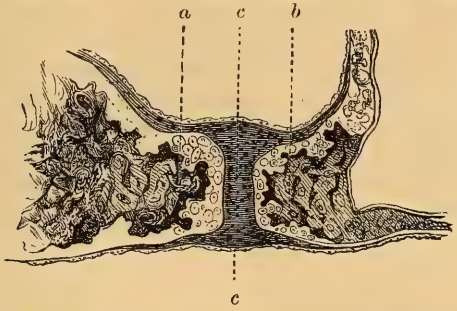

FIG. 33.—SECTION OF THE STAPEDIO-VESTIBULAR ARTICULATION.

a, Margin of the fenestra ovalis covered with a cartilaginous layer; *b*, Margin of the foot-plate of the stapes covered with a cartilaginous layer; *c*, *c*, Section of the ligament. orbic. stapedis.

is developed from the capsule of the labyrinth, while the outer part comes from a ring-shaped deposit at the side of the capsule.

i. Ligaments of the Ossicula.

Besides the above-described capsular ligaments, which connect the articular extremities of the ossicula, there are also to be enumerated some ligamentous ties between the walls of the tympanic cavity and the ossicula, which hold the latter in their position, and act as check-bands in case of too great excursion of these bones. 1. The *superior ligament of the malleus*, a rounded band, which extends from the superior exterior wall of the tympanic cavity to the head of the malleus; it prevents the handle of the malleus from being turned too much outwards. 2. The *anterior ligament of the malleus* (Fig. 34, *la*). According to Helmholtz it is a short and very broad fibrous ligament, which, encircling the stump of the long process of the malleus, is inserted into the parts of the head and neck of the malleus which are directed forwards. It should be regarded as the residuum of the embryonal process. Mecklii. The investigations of Sapolini and Verga go to prove this, as they describe a ligamentum malleo-maxillare, which extends from the malleus through the Glaserian fissure to the lower jaw. 3. *External ligament of the malleus* (Helmholtz) (Fig. 34, *le*). This forms, according to Prussak, the upper boundary of the so-called superior pouch of the membrana tympani. and is stretched out between the crista capitis mallei and the exterior wall of the tympanic cavity. It is also useful in preventing the handle of the malleus from being turned too much outwards. Helmholtz calls the posterior strands of this ligament the posterior ligaments of the malleus. A line passing through the latter, if prolonged through the malleus, would intersect the middle fibrous prolongations of the anterior ligament, and as the axis on

which the malleus turns passes through these two fibrous prolongations. Helmholtz calls them the ligaments of the axis of the malleus. 4. *Posterior ligament of the incus* (Fig. 35, *b*, *b'*). The short process of the incus, covered with a thin layer of fibrous cartilage, leans on the saddle-shaped depression of the posterior wall of the tympanic cavity, at the entrance to the mastoid process. Of the fibrous prolongations, which connect the short process with the osseous wall, the fibrous bundle extending between the short process and the exterior wall of the fissure is especially strongly developed.

The attic or cupola of the tympanum is divided by the articulation of the malleus and incus into two parts. The one lying between the articulation and the external wall was described by me as the external attic. This is formed above by the ligamentum mallei superior and the fold of the incus,

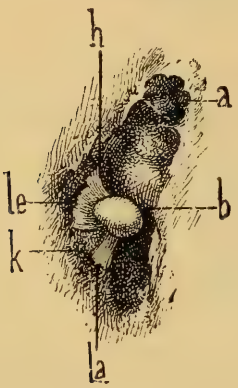

FIG. 34.—LIGAMENT. MALLEI ANTER. ET EXTERN.

b, Head of the malleus; *la*, Ligament. mallei anter.; *le*, Ligament. mallei extern.; *h*, Its posterior portion; *k*, Osseous tip of the spina tympan. post. (major), projecting between the ligament. mall. ant. et extern.; *a*, Antrum mast. After a preparation in my collection. (Right ear.)

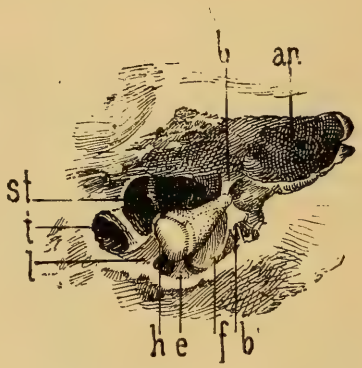

FIG. 35.—LIGAMENTOUS APPARATUS OF THE MALLEUS AND INCUS.

h, Head of the malleus; *l*, Ligament mall. ant.; *e*, Ligament. mall. ext.; *f*, Outer fold of the incus; *b*, inner, *b'*, outer portion of the ligament. incud. post.; *t*, Tendon of the musc. tens. tymp.; *st*, Incudo-stapedial connection; *an*, Antr. mast. After a preparation in my collection.

in which occasionally there are several openings (Fig. 35), and appears to a certain degree separated from the inner portion. The outer attic is divided into an upper (Fig. 36, *m*, *h*) and a lower (*r*). The latter is known as Prussak's space, and is bounded internally by the neck of the malleus, beneath by the short process of the hammer (*k*), externally by the membrana Shrapnelli, and above by the ligament. mall. ext. and the system of cavities first described by me (*W. med. Wochenschrift*, 16, 1870). These cavities are formed by a number of inconstant folds and bridges of mucous membrane, which are stretched between the malleo-incudal articulation to the opposite wall of the niche. Prussak's space communicates on one side with the upper part of the attic, on the other with the posterior pocket of the membrana tympani, and opens into the tympanum at the posterior part by a small round or slit-like

opening, which is hidden by the incus. The external attic, the anatomical relations of which will be made clear by the accompanying cut (Fig. 37), is occasionally the seat of a protracted suppuration, with perforation of Shrapnell's membrane.

k. Intra-tympanic Muscles.

The tensor tympani arises in front of the anterior orifice of the *canalis pro tens. tymp.* on the osseous wall of the pyramid adjacent to the carotid canal, and from the cartilaginous Eustachian tube. The rounded tendon of this penniform muscle leaves the canal at the rostrum cochleare, extends in a direction almost at right angles to the belly of the muscle across the tympanic cavity (Fig. 38), and is inserted on the inner margin of the handle of the

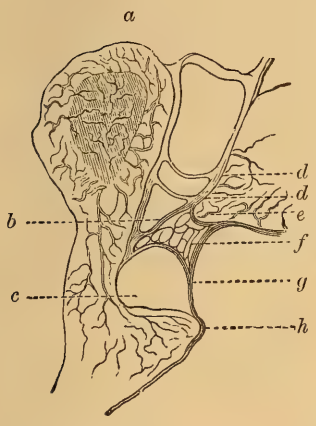

FIG. 36.—SYSTEM OF CAVITIES BETWEEN THE MEMBRANA TYMPANI AND THE NECK OF THE MALLEUS.

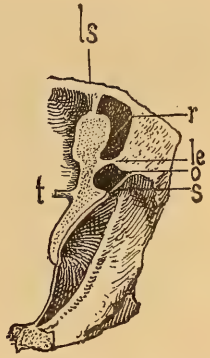

FIG. 37.—PRUSSAK'S SPACE, SECTION THROUGH THE TYMPANIC MEMBRANE, MALLEUS, UPPER AND OUTER TYMPANIC WALL OF A DECALCIFIED PREPARATION.

ls, Ligament. mall. super ; *le*, Ligament. mall. ext. ; *s*, Membrana Shrapnelli ; *o*, Prussak's space ; *r*, System of cavities between the body of the malleus and incus and the external tympanic wall ; *t*, Tendon of the musc. tens. tymp. After a preparation in my collection.

malleus, at the anterior edge of the rhomboidal surface, in an oblique direction to the longitudinal axis of the malleus.

The tendon of the musc. tens. tymp., which can be followed some distance into the canal, lies in its free course in a sheath (Toynbee's tensor ligament). Henle found this sheath connected with the tendon by considerable prolongations of connective tissue. Sometimes, but by no means constantly, the anterior portion of the tensor tympani is connected with the tensor veli palatini, either immediately or by tendinous tissue (L. Meyer).

The stapedius muscle has its origin in the eminentia pyramidalis (Fig. 39), situated on the posterior wall of the tympanic cavity. This muscle appears in longitudinal sections generally pyriform, in transverse sections generally trilateral or prismatic, and with rounded angles. The bundles, arising from the muscular sheath, extend from the floor and the lateral walls of the cavity upwards and towards the middle of the muscle, and merge into the tendon of the stapedius, the tissue of which can often be traced beyond the middle of the muscle. This thin tendon passes through the aperture situated at the point of the eminentia pyramidalis, and is inserted into a point between the capitulum and the posterior axis of the stapes. The external fibres of the tendon (Fig. 32) proceed to the capsular ligament and

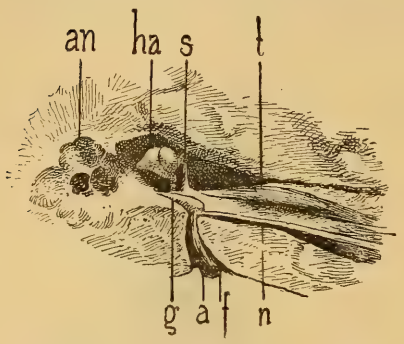

FIG. 38.—VIEW OF THE TYMPANIC CAVITY AFTER REMOVAL OF THE TEGMEN TYMP.

ha, Malleo-incudal articulation; *t*, Musc. tens. tymp.; *s*, Tendon of the musc. tens. tymp. passing across the tympanum; *f*, Nerv. facialis; *g*, Genu nervi facialis; *n*, Nerv. petros. superf. major; *a*, Nerv. acusticus; *an*, Antrum mast. After a preparation in my collection. (Right ear.)

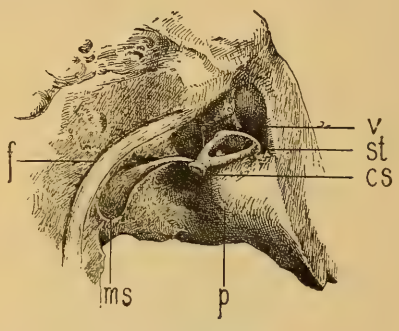

FIG. 39.—POSTERIOR PORTION OF THE INNER TYMPANIC WALL.

st, Stapes; *cs*, Capitulum stapedis; *ms*, Musc. stapedius in the cavitas stapedii, with its tendon inserted at the capitulum; *p*, Promontory; *f*, Nervus facialis; *v*, Vestibule laid open. After a preparation in my collection. Enlarged to double its size. (Right ear.)

the ossiculum lenticulare. Zuckerkandl states that adipose tissue is found between the muscle bundles of the tensor and the stapedius.

In the new-born infant there is found an immediate communication between the inferior portion of the muscular cavity and the facial canal; in adults either one or more oblong fissures between the eminentia stapedii and the canalis facialis will be found. The nerve of the stapedius passes either through one of these fissures, or through a separate small aperture, on its way from the facial nerve to the muscle.

It being a disputed point whether the motor elements of the nerve from the otic ganglion to the tensor tympani belong to the facial nerve (Longet) or to the trigeminus (Luschka), I determined to investigate the question experimentally in Prof. Ludwig's laboratory.* These experiments were conducted

* Compare the complete account of these experiments as given in the report of the *Wiener Academie der Wissenschaften* vom 14 März, 1861.

on the heads of dogs which had just been killed, and gave the following results:

1. That the tensor tympani is supplied by the motor portion of the fifth nerve.

2. That the central fibres of the stapedius muscle are under the control of the facial nerve.

l. Lining Membrane of the Tympanic Cavity.

The lining membrane of the tympanic cavity in the adult appears as a thin transparent pellicle, which in some parts is connected closely with the osseous walls, in others is more easily detached from them. The epithelium of the

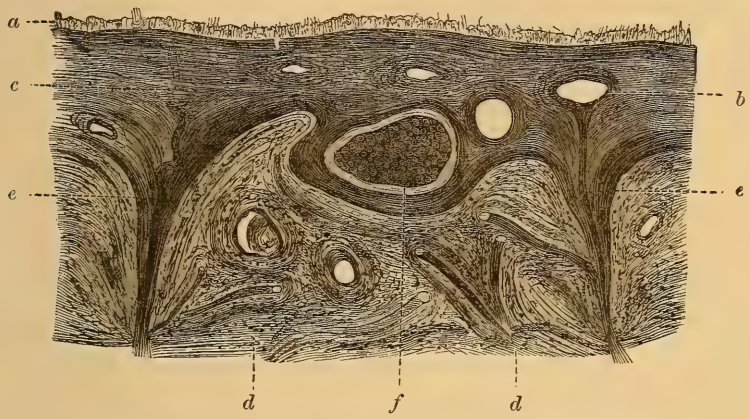

FIG. 40.—SECTION OF THE LINING MEMBRANE OF THE ANTERIOR WALL OF THE TYMPANIC CAVITY.

(Decalcified and prepared with osmic acid.)

a, Epithelium; *b*, Section of a bloodvessel in the stratum of connective tissue, from which a branch penetrates into the funnel-shaped depressions of the bone; *c*, Bloodvessel on the surface, penetrating into the bone; *d*, *d*, Osseous wall; *e*, *e*, Funnel-shaped depressions in the bone, into which the stratum of connective tissue of the lining membrane penetrates; *f*, Section of a large nervous stem in the stratum of connective tissue of the lining membrane.

lining membrane in the inferior portion of the tympanic cavity is ciliated and cylindrical, but in passing upwards it gradually changes into the ciliated pavement variety.

The stratum of connective tissue of the lining membrane of the tympanic cavity (Fig. 40), in which the bloodvessels, lymphatic vessels, and nerves ramify, is composed of two layers, of which the inferior must be considered as the periosteum of the osseous wall. At certain places, especially at the ridgy inferior and anterior wall, I found (*A. f. O.*, vol. v.), in the upper layer of the connective-tissue stratum, networks of fibres similar to the framework of the membrana tympani.

The lining membrane of the tympanic cavity is an immediate continuation of the mucous membrane of the pharynx and of the Eustachian tube. In a considerable number of the ears which I have examined, there were glandular elements only in the anterior part of the tympanic cavity, in the region of the tube, and occasionally upon the promontory. These are not constant, and are never found in the posterior part of the cavum tympani or mastoid cells.

Vascular folds of mucous membrane extend from the walls of the tympanic cavity to the ossicula, which thus receive a covering from the lining membrane of that cavity. The most prominent of these folds are the following: a membrane extending from the superior exterior wall to the head of the malleus and to the superior margin of the body of the incus, also a fold (not constant) passing from the incus to the inner wall of the tympanic cavity; one from the crista transversa to the tendon of the tensor, and a duplicature from this to the anterior pocket of the membrana tympani; and lastly the

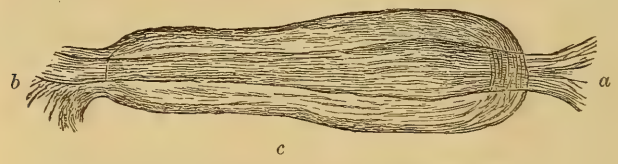

FIG. 41.—OVAL BODY IN THE MIDDLE EAR.

a, Entrance of the stalk; *b*, Exit of the stalk; *c*, Constricted part of the body.

fold of the stapes, which is spread between the crura of the stapes (lig. obturat. stapedis) and over the posterior crus and the tendon of the stapedius. There is an inconstant membranous framework, which I first discovered as extending from the head of the malleus and body of the incus and the outer attic to the mastoid antrum. Purulent inflammation in the external attic can extend to the mastoid antrum by means of this framework, and the opposite may occur from the mastoid antrum to the attic and Prussak's space.

Besides the above-named folds of mucous membrane, I found in the tympanic cavity a number of inconstant prolongations of connective tissue, which have formerly been considered as pathological products, but which I was the first to prove to be (*Beleuchtungsbilder des Trommelfells*, 1865) a residuum of the gelatinous connective tissue which fills the middle ear in the fœtal state. Such bridges and strings often occur between the membrana tympani and inner wall of the tympanum, and between the handle of the malleus, long process of the incus, and stapes. Almost always there are string- or band-shaped attachments between the crura of the stapes and walls of the pelvis ovalis, which favour the formation of adhesions in inflammatory prosesses. Upon these connective tissue structures I discovered with the microscope peculiar formations, previously unknown. These formations (Fig. 41) are usually oval, sometimes a little constricted in one or more places (*c*), pyriform, and in rarer cases triangular; occasionally both these shapes are combined in one specimen. These small bodies are covered with epithelium,

and have, superficially as well as in section, a fibrous structure, arranged in layers parallel with the exterior outline. Between the layers, spindle-shaped bodies are to be seen.

A fibrous stalk (*a*) of varying size arises with a broad base from the membranous surface below, enters into the rounded extremity of this body, and traversing it, issues at the other extremity and is inserted into a membrane or into the osseous wall opposite. Sometimes one stalk traverses several of these bodies, or is divided into two stalks when issuing. The size of these bodies varies between 0·1-0·9 mm. and upwards. These bodies I found mostly in the posterior portion of the tympanic cavity, in the antrum mastoideum, also in the upper tympanic space, on the membrana tympani, and in Prussak's space. These bodies were first discovered by me (*Wien. med. Wochenschrift*, Nov. 20, 1863), but were later described by Kessel and others.

The lining membrane of the tympanum in the new-born infant is remarkable for an abundance of vessels, as also for great tumefaction of the tissue (Brunner). In places which are perfectly smooth in the adult, for instance on the promontory, are often found densely packed papillæ of the same structure as those described as occurring on the membrana tympani (p. 26).

Moos succeeded in seeing tufts of bloodvessels in the mucous membrane of the membrana tympani. The great swelling and vascularity are connected with the evolutional processes which take place in the middle ear in the fœtal state and after birth. For the fœtal tympanic cavity is filled with a gelatinous mass, which on microscopic examination presents the characters of undeveloped connective tissue, spindle-shaped cells in a structureless, gelatinous, fundamental substance. This tissue, designated by Wendt as a proliferation of the mucous lining of the wall of the labyrinth, often displays, even before birth, the appearance of incipient decay, fatty degeneration having already commenced in the epithelium of the lining membrane of the middle ear and in this gelatinous tissue. After birth a rapid degeneration of the gelatinous substance into a yellowish-green, thickish fluid is caused by the entrance of air into the tympanic cavity. This fluid contains fat and pus corpuscles. As investigations have shown, in the great majority of new-born infants there is found in the tympanic cavity a pus-like substance, which is reabsorbed in a few weeks after birth by the highly vascular mucous membrane. The statement that in all these cases a purulent inflammation of the middle ear is present (Netter) is in no wise proved. The opinion I advanced, that in most of these cases it was a degenerative process and not a purulent inflammation, was sustained by the bacteriological investigations of Gradenigo and Penzo (*Z. f. O.*, Bd. 21, S. 298).

m. Vessels and Nerves of the Tympanic Cavity.

The arteries which supply the lining membrane and the structures in the tympanic cavity spring from various vessels. The anterior and middle portions of the tympanic cavity are supplied (1) by the tympanic artery (from the external maxillary), which enters the tympanum through the Glaserian fissure; (2) by the ascending pharyngeal (from the external carotid), which

penetrates the floor of the tympanum, runs over the promontory, and ascending to the tegmen tympani anastomoses with the middle meningeal; (3) by the branches of the ascending pharyngeal artery (from the external carotid); (4) by branches of the middle meningeal artery, which penetrate through the *hiatus canalis Fallopiæ* and the fissura petroso-squamosa into the tympanic cavity, and (5) by the internal carotid, which sends a few small branches through minute vascular orifices of the carotid canal in the petrous bone into the tympanic cavity. The stylo-mastoid artery, which penetrates into the Fallopian canal, supplies the neurilemma of the facial nerve and the stapedius muscle, and also sends small branches to the lining membrane of the tympanic cavity and mastoid cells, and anastomoses, through the apertur. spur. canalis Fallopii, with the middle meningeal.

The veins of the cavum tympani pass (1) into those of the external meatus by means of numerous anastomotic branches which perforate the membrana tympani; (2) into the venous plexus (Rektorzik), which surrounds the internal carotid in the carotid canal; (3) into those of the dura mater through the fissura petrosa-squamosa, and (4) into the venous plexus of the lower jaw.

According to the investigations made by Prussak on dogs, the arteries often pass into the veins without the intervention of capillaries. The veins of the lining membrane are very tortuous, and show here and there considerable pouch-like dilatations of their lumen.

To determine the relation of the bloodvessels of the mucous membrane to the osseous walls of the tympanic cavity, I undertook a series of anatomical examinations,* which led to the result that vascular connections are kept up between the middle ear and the labyrinth through the osseous wall separating them.

In microscopic sections of the wall of the labyrinth, prepared with osmic acid and decalcified, the bloodvessels of the middle ear can be seen proceeding from the deeper layers of the lining membrane, accompanied by numerous prolongations of connective tissue, penetrating almost perpendicularly into the funnel-shaped mouths of the canals of the osseous wall (Fig. 40, *e*, *e*). If the inner wall of the tympanic cavity, prepared with osmic acid, is closely scrutinized, even with the naked eye small black dots will frequently be found between the ramifications of the nerves and the vessels, which on closer examination appear as the culminating points of a number of vessels. The vessels of the osseous wall, then, form a connection on the one hand with the bloodvessels of the lining membrane of the middle ear, on the other with the vessels of that of the labyrinth.

This relation of the lining membrane of the tympanic cavity and its bloodvessels to the osseous wall is frequently of considerable importance, as there can be no doubt but that hyperæmia and congestion of the vessels of the middle ear, accompanied with inflammation, owing to these anastomoses, sometimes extends to the vascular regions of the labyrinth, causing there temporary or permanent disturbances of nutrition.

* *Ueber Anastomosen zwischen den Gefässbezirken des Mittelohrs und des Labyrinths*, *A. f. O.*, vol. xi.

Up to the present but little is known of the lymphatic vessels of the cavum tympani.

Besides the sensory fibres of the trigeminus, the sympathetic and the glosso-pharyngeal nerves take part in the supply of the lining membrane of the middle ear. Of these three, the branch of the latter nerve to the tympanic cavity is the one most highly developed. From the jugular fossa it enters the tympanic cavity through an orifice in the inferior wall, and extends upwards in the groove on the promontory to unite with the nerv. petros. superf. minor. In this, called Jacobson's nerve, Pappenheim, Kölliker, and Krause (*Zeitschrift f. rat. Medicin*, 1866, p. 92) have traced ganglion cells inserted at intervals. W. Krause found a moderately large branch passing from the tympanic plexus to the cartilaginous Eustachian tube; and I saw several times such a branch pass directly from Jacobson's nerve.*

The sympathetic nerves of the lining membrane of the middle ear spring from the sympathetic plexus, which accompanies the carotid artery in its canal. By means of orifices in the canal several small branches of this plexus enter the tympanic cavity as nervi carotico-tymp., to form in its anterior portion, together with the ramifications of Jacobson's nerve and the n. petros. superf. minor, the plexus tympanicus. From this proceed the finer nerves for the whole lining membrane of the middle ear. On the promontory, especially near the fenestra ovalis, clusters of ganglion cells are inserted in these nervous bundles. Besides the latter, a delicately ramifying network of nerve-fibres is seen, which spreads partly above and partly below the vessels, and forms ganglionic swellings at places where several fibres meet.

B. The Eustachian Tube.

The *Eustachian tube* forms the connection between the tympanic cavity and the pharynx. It is the passage by which an exchange of air takes place between the external atmosphere and the tympanic cavity.

The Eustachian tube consists of an osseous and a cartilaginous portion. Its position is oblique, having, according to Henle, a direction almost exactly diagonal between the horizontal and the vertical, the axis of the tube forming an angle of 135° with the horizontal axis of the meatus, and one of 40° with the horizon. The tympanal opening of the Eustachian tube is about 2·5 cm. higher than the pharyngeal opening.

The length of the whole canal can only be determined approximately, because the commencement of its osseous portion in the tympanic cavity is not sharply defined; it amounts generally to 34-36 mm., of which the cartilaginous portion forms two-thirds. The narrowest part, the *Isthmus tubæ*, which is situated in the cartilaginous section in front of its point of union

* Compare Bischoff, jun., *Mikroskopische Analyse der Anastomosen der Kopfnerven*, München, 1865.

with the osseous portion, measures in the corrosion preparations prepared by Bezold 3 mm. in height, and not more than $\frac{1}{4}$ mm. in width. Its distance from the ostium pharyngeum averages 24-26 mm.

a. The Osseous Portion of the Eustachian Tube.

The osseous portion of the Eustachian tube, bounded above by the canal of the tensor tympani, and below and towards the middle by the carotid canal,

FIG. 42.—EUSTACHIAN TUBE AND TYMPANIC CAVITY.

a, Membrana tympani ; *b*, Head of the malleus ; *c*, Lower end of the handle of the malleus ; *d*, Body of the incus ; *e*, Short process of the incus ; *f*, Tensor tympani ; *g*, Ostium pharyngeum tubæ ; *h*, Isthmus tubæ ; *i*, Ostium tympanicum tubæ. (Right ear.)

is a prolongation of the anterior portion of the tympanic cavity directed inwards. The boundary between the tube and the cavity, however, is not a very marked one, because the superior and lateral walls of the latter merge without interruption into the former. On the under-side the boundary is better defined, especially where the obliquely rising anterior wall of the tympanic cavity curves towards the inferior wall of the osseous tube (Figs. 42 and 43, *ot*). Above this place is situated the *ostium tympanicum tubæ Eustachii*, irregularly defined and inconstant in size ; its height, according to Bezold, is 4·5 mm., its width 3·3 mm. The lumen of the osseous canal,

the diameter of which, according to Henle, amounts to about 2 mm., becomes only slightly less towards the place of union with the cartilaginous portion of the tube, and shows in the transverse section an irregularly trilateral outline. (L. Mayer.*)

b. The Cartilaginous Portion of the Eustachian Tube.

The cartilaginous portion of the Eustachian tube is attached to the rough, irregular, and oblique margin of the anterior extremity of the osseous portion; laterally its walls approach nearer to the tympanic cavity than in their inferior part, because the lateral wall of the osseous part of the tube is shorter than

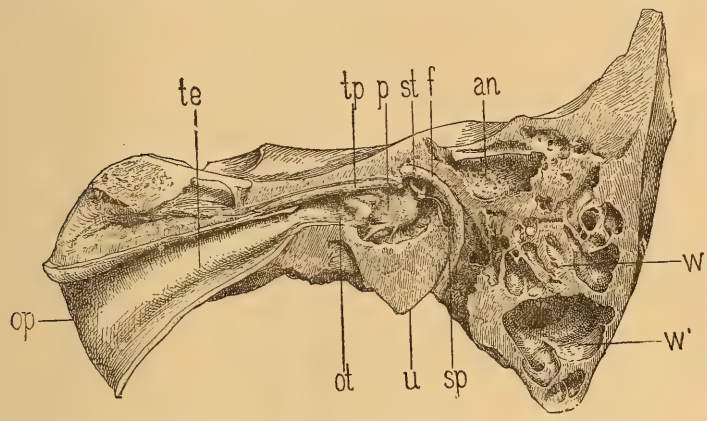

FIG. 43.—SAGITTAL SECTION THROUGH THE ENTIRE MIDDLE EAR OF AN ADULT, INNER HALF.

op, Ost. pharyng. tubæ; *te*, Canalis tubæ Eust.; *ot*, Ost. tymp. tubæ; *tp*, musc. tens. tymp.; *p*, Promontory with the anastomos. Jacobsonii; *u*, Lower wall of the tympanic cavity; *st*, Stapes; *sp*, Musc. stapedius; *f*, Facial nerve; *an*, Antrum mastoid.; *w*, *w'*, Mastoid cells. After a preparation in my collection. (Left ear.)

the inferior wall. This part of the tube is not in its whole extent cartilaginous, the groove-like cartilage being formed into a canal by a membranous plate.

The cartilaginous plate, turned in at its superior margin, forms a narrow groove near its insertion into the osseous portion, the outer wall of which is broader than its inner wall; farther down, however, a few lines distant from the osseous tube (at the spina angularis, Henle), the height of the inner cartilaginous wall rapidly increases, while the outer wall along the superior margin of the cartilaginous plate forms a narrow turned-in stripe (Fig. 44, *b*), which roofs over the Eustachian tube. At a superficial view the cartilage of the tube appears triangular in shape, its apex resting on the osseous tube, while its base is prominent as a rounded bulging on the lateral wall of the pharynx. The portion of the cartilage near the osseous tube is attached to the basilar fibro-cartilage, and is less movable than the inferior broader portion standing out from the base of the skull. The cartilage itself, composed on the surface of hyaline, and in the deeper layers of a fibrous funda-

* *Studien über die Anatomie des Canalis Eustachii*, 1866.

mental substance, shows very often a number of irregular fissures, clefts, and sometimes disruption of the cartilage of the tube into several separate pieces. Moos and Zuckerkandl describe several accessory cartilages lying in the region of the cartilago-membranous portion of the tube.

The Eustachian canal in the child differs considerably as regards length, width, and direction from that in the adult. Its length in the newly-born measures 18-20 mm., of which 8-9 mm. belong to the osseous, and 11-12 mm. to the cartilago-membranous portion. Its tympanic orifice is comparatively large, and lies somewhat lower; on the other hand, the pharyngeal orifice is indicated only by a slight depression or fissure, and the posterior prominent

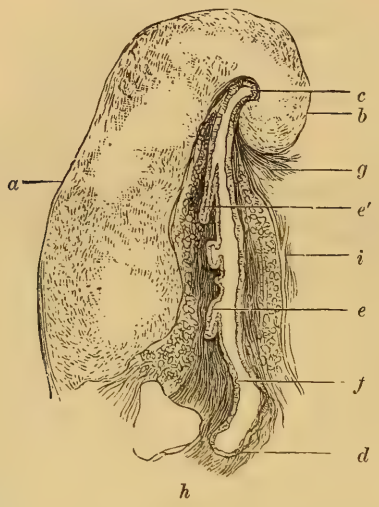

FIG. 44.—TRANSVERSE SECTION OF THE CARTILAGINOUS EUSTACHIAN TUBE.

a, Central cartilaginous plate; *b*, Cartilaginous hook; *c*, Space below the cartilaginous hook; *d*, Base of the Eustachian tube; *e*, *e'*, Folds of mucous membrane; *f*, Cylindrical epithelium; *g*, Musc. tensor palat. mollis; *h*, Musc. levator palat. mollis.

portion of the tube forms a hardly noticeable projection on the wall of the pharynx. The tube in the child is also shorter and wider, a condition which is of practical importance in so far as obstacles in it, caused by the products of disease, can with greater facility be removed by a current of air.

The relation of the membranous portion to the cartilaginous plate is most clearly shown by transverse sections of the tube. Examining the anatomical relations of the cartilaginous tube by this method, v. Tröltsch, Moos, Henle, Rüdinger, and L. Mayer have brought to light a number of very interesting anatomical facts. In such a transverse section (Fig. 44) we see in the first instance the central cartilaginous plate (*a*), twisted round like a hook (*b*) at its superior margin. At the end of this hook commences the membranous portion of the tube, delicate and thin near the cartilage, increasing, however, in thickness downwards, and mostly supported by an abundant adipose and glandular layer. The membranous portion, which merges below into the salpingo-pharyngeal fascia, according to v. Tröltsch forms the smaller half of

the circumference of the Eustachian tube, and constitutes, together with the cartilaginous hook, the lateral wall of the cartilaginous portion of the tube (*i*), and also its base (*d*). The portion of the membranous tube lying in the region of the osteum tubæ is much thinner than the upper portion, where it receives fibrous tissue from the spina angularis of the sphenoid, and also an accessory cartilage.

By reason of this hook-like twist of the cartilage, a space is formed below it, the proportions of which vary in the several portions of the Eustachian tube. In transverse sections of hardened preparations in the superior portions near the osseous part a small space will be found below the curvature of the hook, the walls of which do not come into contact with each other. In the middle portion, however, the central and lateral walls of the tube are completely in contact, and only near the ostium pharyngeum do the walls again diverge a little.*

The mucous membrane of the membranous portion of the Eustachian tube has an abundance of folds in its lower portion. According to Moos, these folds of the membranous portion form a bulging immediately behind the ostium pharyngeum, which closes the tube in this place, when at rest. Above, the abundance of folds gradually decreases.

Lining Membrane of the Eustachian Tube.—The walls of the Eustachian tube are covered by a glandular mucous membrane with a ciliated cylindrical epithelium. The lining membrane of the osseous tube is smooth and closely united with the periosteum. The mucous membrane of the cartilaginous plate is more strongly developed, and a great number of acinous glands discharge on its surface (Fig. 44, *i*, *e*). These glands extend to the neighbourhood of the perichondrium, but sometimes, especially near the orifice in the pharynx, they can be traced through fissures in the cartilage of the tube, into the connective tissue outside the tube. These glandular elements are most numerous near the orifice of the tube in the pharynx, while in the osseous portion, especially towards the tympanic cavity, they are much less abundant. Besides this, Gerlach found in the mucous membrane of the child sebaceous glands, the walls of which consist of a diffuse conglomerate glandular substance, and which occur in great numbers in the whole cartilaginous portion of the tube. Gerlach proposes to name these sebaceous glands tonsils of the tube, as they are analogous to the pharyngeal tonsils of Luschka.

Muscles of the Eustachian Tube.—The lumen of the Eustachian tube, the walls of which are in contact with each other, sometimes more, sometimes less intimately, is temporarily opened by a muscular apparatus. This is principally produced by the levator and tensor palati mollis.

The first of these, the levator palati mollis (*petro-salpingo-staphylinus*), arises from the surface of the petrous bone next the carotid canal. Its rounded belly extends parallel to the Eustachian tube, is closely applied partly to the membranous portion (Fig. 45, *l*, *k*), which forms the base of the tube, partly to the cartilaginous plate, and is inserted in a radiating manner into the soft palate below the orifice of the tube in the pharynx. None of

* Compare v. Tröltsch, *Arch. f. Ohrenheilk.*, vol. ii., and v. Moos, *Archiv. f. Augen. und Ohrenheilk.*, vol. i.

its fibrous bundles arise, as was formerly believed, from the Eustachian tube, for it is only attached to it by a short band of connective tissue. The action of the levator palati mollis is not confined to the velum palati alone, for the base of the Eustachian tube is raised at every contraction of the muscle, by which the orifice of the tube is made smaller, but the resistance in the tube is lessened owing to the shortening and widening of its aperture.

The tens. palat. moll. (*spheno-salpingo-staphylinus s. circumflexus palat.*)

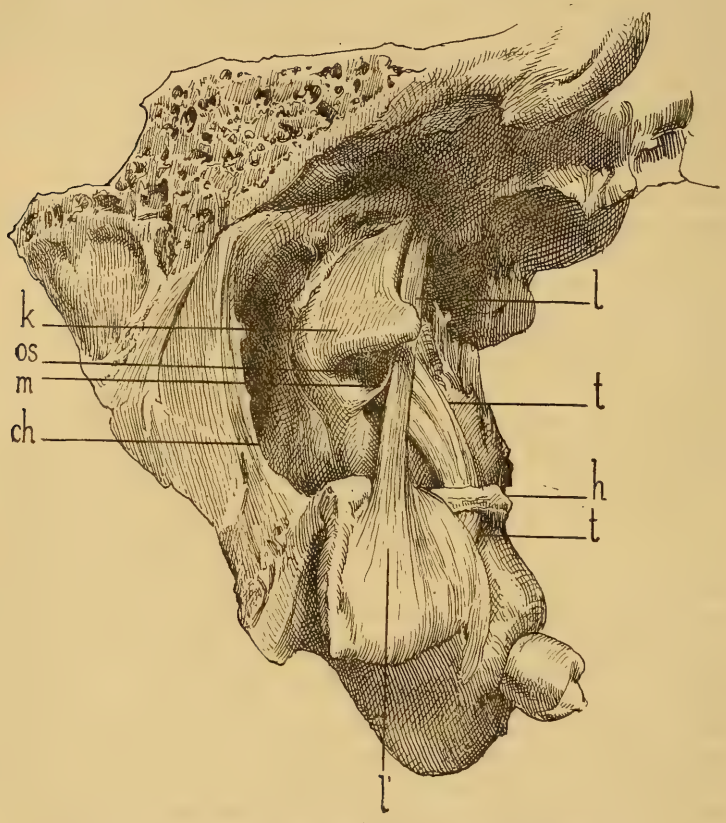

FIG. 45.—EUSTACHIAN TUBE WITH ITS MUSCLES (NATURAL SIZE).

k, Cartilaginous plate of the Eustachian tube; *m*, Pars membranacea of the Eustachian tube; *os*, Ostium pharyng. tubæ; *ch*, Choana; *l*, Musc. levator palati mollis; *l'*, Radiation of the levator in the velum palati; *h*, Hamulus pterygoideus; *t*, *t*, Musc. tensor palati mollis, winding round the hamulus. After a preparation in my collection. (Right side.)

has its origin at the inferior surface of the sphenoid bone; a great number of its bundles, however, come from the short, hook-like part of the lateral cartilaginous wall (Fig. 45, *t*, *t*), and from the membranous part of the cartilaginous portion of the tube. In its downward course its flat belly lies close to the lateral wall of the membranous portion of the tube, and is rather firmly

attached to it. The direction of the fibres of the belly, the tendon of which is coiled round the hamulus pterygoideus, and radiates in the fibrous prolongation of the hard palate (Henle), forms an acute angle with the direction of the cartilaginous portion of the tube. The tendon of the muscle is attached so tightly to the hamulus pterygoideus, that the effect of the muscular contraction is greater in the Eustachian tube than in the soft palate. By the contraction of this muscle the cartilaginous hook is slightly unfolded, the membranous portion of the tube is lifted up a little from the cartilaginous portion, and the lumen of the tube is opened. V. Tröltsch, who first drew attention to the importance of the anatomical relations to the physiological function of the Eustachian tube, proposes the name 'abductor' or 'dilatator tubæ' instead of the hitherto current tensor palati mollis. There remains to describe the salpingo-pharyng. muscle, which extends from the palato-pharyngeus muscle to the prominence at the ostium pharyngeum.

In connection with the muscles of the Eustachian tube are three fasciæ, which play an important part in the opening of the tube, and which are partially inserted in it. 1. The fascia salpingo-pharyngeus (v. Tröltsch) which extends from the ridge of the tube to the hamulus pterygoideus, and separates the tensor from the levator muscle; 2. The external fascia of the tensor (Weber-Liel); and 3. That fascia which is intimately connected with the ligam. salpingo-pharyngeus, and borders on the median surface of the levator muscle.

The arteries of the Eustachian tube proceed from the ascending pharyngeal and the middle meningeal. The veins communicate with those of the cavum tympani and the naso-pharynx, and, anastomosing with the sinus cavernosus, form a plexus which, when over-filled with blood, changes the calibre of the tube to a considerable extent.

C. The Mastoid Process.

The mastoid process forms the posterior portion of the middle ear. The conically-shaped cellular process is wanting in the newly-born infant, being represented by that nipple-like portion which is preformed in the embryo. The absolute mastoid process originates as a small tubercle on the temporal bone of the infant behind the superior termination of the annulus tympanicus. Partially by its individual growth, and partially from muscular action in the first years of life, it grows downward, but does not acquire the typical shape of the mastoid process of the adult until the third year (Zuckerkandl).

Between the anterior surface of tuberculum mastoideum and that posterior portion of the pars squamosum which, according to Toynbee, forms the anterior wall of the mastoid antrum in the newly-born child, lies the sutura mastoidea-squamosa. This was described by Dr. Verney, and generally disappears during the first years of life, although sometimes persistent in the

adult as a jagged and deep-seated furrow on the outer surface of the mastoid process.

The mastoid antrum, the only one of the pneumatic spaces present in the newly-born child, is a longish cavity, 5 mm. in width, situated behind, and higher than the cavum tympani. According to Zuckerkandl, the development of the cellular spaces in the mastoid process takes place in the following manner: The cellular proliferation commences at the upper posterior periphery of the mastoid antrum, and then proceeds towards the outer lamella. According to Schwartze and Eysell, the mastoid cells are arranged during their development in a typically radiar manner towards the mastoid antrum, but this arrangement is seldom recognisable in the adult, because of the formation of new osseous septa and the disappearance of others already developed.

The complete mastoid process is divided by anatomists into two portions: the horizontal portion or mastoid antrum is a large, somewhat lengthy

Fig. 46.

irregular space, situated below the tegmen mast., and reached through the triangular orifice in the posterior wall of the tympanic cavity; the vertical portion has cellular spaces which communicate with the antrum.

Both the size and shape of the mastoid process present many variations. In some cases it is massively developed, in others it is reduced to a short solid protuberance. Considerable differences are also found in the contents of the process, which may be composed, not of pneumatic spaces, but of a spongy, fatty, or compact osseous substance. Zuckerkandl found that of 250 temporal bones examined by him in only 36·8 per cent. did the mastoid process contain pneumatic spaces alone. In 43·2 per cent. it was partially diploëtic, and partially pneumatic, and in 20 per cent. it was entirely fatty, diploëtic or sclerosed.

We therefore differentiate three principal types of the mastoid process: the pneumatic, the diploëtic, and the combination of the two or mixed form. The pneumatic mastoid process is often composed of a large number of irregular cellular spaces, penetrating the temporal bone in all directions and covered by a thin external osseous lamella (Fig. 46). In other cases the whole process consists of one or two large cavities, or of numerous small cavities, together

with one or more larger ones, which, either at the apex or inner side, give a dome-shape to the roof. Frequently large cavities communicate with the antrum by a narrow canal only.

A satisfactory idea of the position of the mastoid cells in the temporal bone

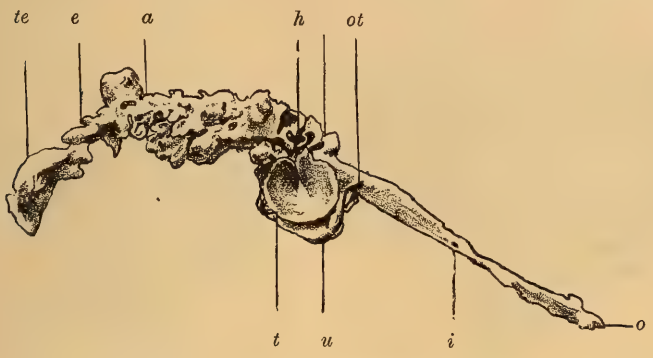

FIG. 47.—CORROSION CAST OF THE MIDDLE EAR (AFTER BEZOLD).

o, Osteum pharyng. tubæ ; *i*, Isthmus tubæ ; *ot*, Osteum tymp. tubæ ; *u*, Lower portion of the cavum tympani ; *t*, Membrana tympani with the depression for the malleus and umbo ; *h*, Cavity for the malleus and incus ; *a*, Posterior end of the mastoid antrum ; *e*, Intercellular space ; *te*, Terminal space.

can only be obtained by means of corrosion preparations. The same remark applies to the topography of the organ of hearing. On this subject we are greatly indebted to Fried. Bezold, whose masterly work, *Die Corrosionsanatomie des Ohres*, Munchen, 1882, cannot be too highly recommended.

The pneumatic cellular cavities starting from the mastoid antrum extend backwards to the sutura occipitalis, surrounding the transverse sinus and the emissarium santorin; downwards to the apex and inner surface of the mastoid process; upwards and forwards to the linea temporalis and the root of the zygomatic process, thereby completely encircling the auditory meatus, with the exception of the lower anterior wall, and extending inwards frequently to the apex of the pyramid. The cellular cavities often surround the labyrinth on all sides, and directly adjoin the bulbus venæ jugularis and the posterior portion of the carotid.

FIG. 48.

The diploëtic mastoid process shows on section a marked difference in appearance, consisting, from its apex (Fig. 48, *c*) to the upper border (*b*), of small-celled diploë and osseous tissue, rich in fatty substances, and only occasionally presenting air cells in the vicinity of the mastoid antrum, which is, as a rule, small. The sclerosed process is seldom compact, generally containing either

very close diploëtic tissue or large single gaps. The diploëtic and sclerotic processes are on an average smaller than the pneumatic.

The third type is represented by the partially diploëtic, partially pneumatic form. Here we have numerous varieties, two of which are most frequently

Fig. 49.

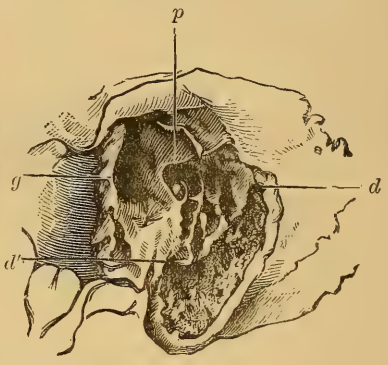

Fig. 50.

met with, viz., that in which the lower portion of the mastoid process is diploëtic and the upper pneumatic (Fig. 49), and that in which the lower and posterior portion (Fig. 50, *d*, *d'*) are diploëtic, the anterior portion (*d*, *p*) containing pneumatic cells.

The pneumatic spaces of the mastoid process are lined with a delicate

Fig. 51.—Vertical Section of the Mastoid Process and the Osseous Meatus.

a, Mastoid cells ; *b*, Posterior wall of the osseous meatus ; *c*, Anterior wall of the osseous meatus.

Fig. 52.—Horizontal Section of the External Meatus and the Tympanic Cavity.

a, Anterior wall of the meatus ; *b*, Posterior ; *c*, Cells of the mastoid process ; *d*, Meatus ; *e*, Membrana tympani ; *f*, Tympanic cavity ; *g*, Fossa sigmoidea. (Right ear.)

membrane, which is a continuation of the mucous membrane of the tympanic cavity, is closely united to the periosteum and has a layer of non-ciliated epithelium. In the antrum are often found membranes and branch-like bands

of connective tissue, on which are the pedunculated bodies discovered by me and described on page 36 (Fig. 41).

The cellular spaces of the mastoid process are bounded in front by the posterior end of the pyramid, the tympanic cavity, and the posterior wall of the osseous meatus, as shown in the accompanying figures (Figs. 50 and 51). The outer wall is formed by that convex osseous plate which can be felt behind the auricle, and which varies very much in extent of surface and thickness (4 to 10 mm.). Where the mastoid process joins the posterior wall of the meatus, *i.e.*, on the posterior superior orifice of the latter, there is found, though not invariably, a pointed eminence, varying in development, and called the spina supra meatum. It serves as an anatomical landmark in operations on the mastoid process.

Posteriorly the mastoid process is contiguous to the occipital bone, in which

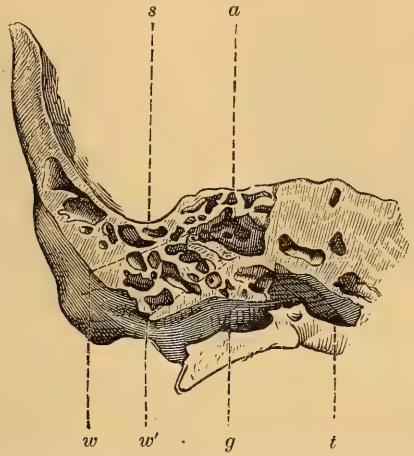

FIG. 53.—HORIZONTAL SECTION THROUGH THE PNEUMATIC MASTOID PROCESS.

g, Posterior wall of the meatus ; *t*, Cavum tympani : *a*, Mastoid antrum ; *s*, Sigmoid sinus ; *w*, *w'*, Basis for operation on the external covering of the mastoid process.

one occasionally finds cellular spaces communicating with the mastoid cells (pneumatic occipital bones, Hyrtl). The upper wall of the mastoid process which faces the cranial cavity is called the tegmen mastoideum, and is formed by the posterior continuation of the tegmen tympani and the inner lamella of the horizontal part of the squamous portion of the temporal bone.

The inner boundary of the mastoid process is made up of two parts, a lower and an upper. To the lower belongs the conical portion of the process, in which a groove is cut (incisura mastoidea), running in a sagittal direction, and intended for the insertion of the digastric muscle. The osseous wall on this side is frequently as thin as paper, so that abscesses can find an outlet in this direction (Bezold). The upper portion of the inner boundary is especially interesting, as it is traversed by the winding course of the sigmoid sinus, which originates at the eminentia cruciata interna of the occipital bone, passes over the inner surface of the mastoid process, and arriving at

the foramen jugulare (lacerum posticum), rises with an abrupt curvature against the inferior wall of the pyramid, where it forms the bulbus venæ jugularis. Suppurative inflammation of the mastoid process, which also attacks its inner wall, may consequently bring about fatal phlebitis of the sinus.

The anatomical varieties in respect to the relative position of the sigmoid sinus to the mastoid process, and the posterior wall of the meatus, are of great practical importance. Bezold and Hartmann have called attention to the fact that the sigmoid sinus is occasionally shifted anteriorly and laterally, so that injury to the same is not easily avoidable in operations of opening the mastoid process. In more than 500 temporal bones which I examined, I found the position of the sinus most favourable when the mastoid process was strongly developed, and entirely filled with pneumatic spaces. In these

FIG. 54. — HORIZONTAL SECTION THROUGH A MASTOID PROCESS, PARTLY DIPLOËTIC, PARTLY PNEUMATIC.

g, Posterior wall of meatus; *a*, Mastoid antrum; *s*, Sigmoid sinus; *w*, *w'*, Basis for operation.

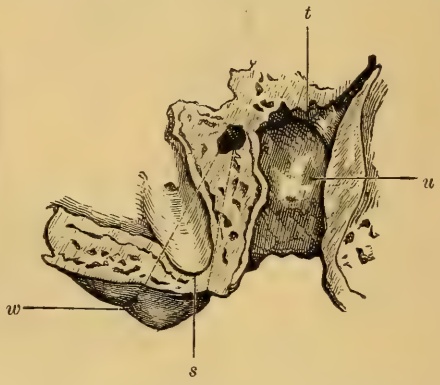

FIG. 55.—HORIZONTAL SECTION THROUGH A COMPACT MASTOID PROCESS, CONTAINING A SMALL AMOUNT OF DIPLOË.

t, Cavum tympani; *u*, Under wall of meatus; *s*, Sigmoid sinus; *w*, Posterior boundary of basis for operation.

cases (Fig. 52) there is a broad space between the sigmoid sinus and the posterior wall of the meatus (*g*), which in operating permits access to the antrum without danger of wounding the sinus. I found the relations to be less favourable in the diploëtic and compact mastoid processes. Here the spaces between the sinus and the posterior wall of the meatus is much narrower (Fig. 54), and in some cases the sinus is shifted so far forwards and outwards as to leave only a small connecting bridge (Fig. 55), with the result that in operating exposure of the sinus is rendered unavoidable.

An abnormally oblique position of the middle cranial fossa produces scarcely any hindrance to the present methods of opening the mastoid process.

The spaces within the mastoid process are supplied by branches of the middle meningeal and stylo-mastoid arteries. The external surface by the post-auricular artery. The external veins are connected partly with the veins on the side of the neck which empty into the jugular, partly with the emissar-

Santorini coming from the cavity of the skull through the pars mastoideum. The veins from the mast. antrum and cells partly anastomose with those of the cavum tympanum and the corticolis partly empty into the emissar-Santorini, and through small canals in the inner wall of the mastoid process into the sigmoid sinus. Besides these is a vascular canal passing from the inner part of the mastoid process beneath the superior semicircular canal, through the fossa subarenata into the cavity of the skull. This is in immediate connection with the diploëtic spaces of the mastoid process. The nerves of the mast. antrum and cells come from the tympanic plexus, those of the external surface from the n. auricularis magnus.

D. Topography of the Sound-conducting Apparatus.

The topography of the auricle is best studied by means of horizontal and vertical sections made from preparations hardened in alcohol. In such preparations the greater portion of the cartilage of the ear will be seen to stand away from the lateral surface of the skull, whereas that portion which surrounds the external opening applies itself to a varying extent to the squamous portion of the temporal bone and the mastoid process. That portion of the auricle which lies above the external auditory orifice, the radix helicis, the anterior superior segment of the concha, and the anterior portion of the fossa intercruralis, is attached to that surface of the horizontal portion of the pars squamosa which proceeds to the squama of the temporal bone, and is crossed by the linea temporalis. The middle segment of the concha, lying behind the external auditory orifice, is attached to the mastoid process to the extent of $1\frac{1}{2}$ to 2 cm. by means of flexible connective tissue. This fact is of importance in so far that this segment of the auricle partially covers that surface of the mastoid process which is used for operating upon, and consequently the auricle must be detached from that portion. That segment of the cartilage of the ear which forms the tragus, and which lies in front of the ext. auditory orifice, is contiguous on its inner aspect to the cartilaginous meatus and the external side of the glenoid fossa.

The cartilaginous meatus is partially enclosed in the osseous meatus. The superior wall of the osseous meatus completely roofs in the cartilaginous portion of the cartilaginous meatus as far as the external orifice of the ear, and in a similar manner the cartilaginous portion is covered in by that outer portion of the posterior wall which is formed by the mastoid process. Consequently, by inserting the finger into the cartilaginous meatus, one is able to feel the superior posterior wall of the osseous meatus directly behind the external orifice. Of the lower and longest wall of the cartilaginous meatus, the external portion alone is palpable, the inner portion being covered by the parotid gland. The anterior cartilaginous wall is in its inferior portion contiguous to the posterior surface of the capsule of the maxillary joint, the excursions of which are communicated to the wall of the meatus.

The superior boundary of the osseous meatus is formed by the middle cranial fossa, the posterior by the cells of the mastoid process and the anterior by the maxillary joint, the cavity of which lies higher than the

lumen of the osseous meatus. The space occupied by the cavity of the joint extends farther out than the osseous meatus.

A thorough knowledge of the topographical relation of the membrana tympani to the inner wall of the tympanic cavity is of great importance to the practitioner, for the proper understanding of pathological changes in the different portions of the tympanic cavity, as well as on account of operation in that cavity and on the membrana tympani. To render the relations of the membrana tympani to the various portions of the inner wall of the cavity more distinct, we divide the outer surface of the membrana tympani (Fig. 56) into four segments, the axis of the handle of the malleus being produced downward and intersected by a horizontal line drawn at a tangent to the lower end of the handle. The projection of the wall of the tympanic cavity with respect to the membrana tympani given by Zuckerkandl* agrees well with the anatomical preparations, but is considerably modified by the inclination of the membrana tympani to the horizontal met with in practice. In the normal position of the head, in which otological experiments are made, we find that:

FIG. 56.—PROJECTION OF THE INNER WALL OF THE TYMPANIC CAVITY WITH RESPECT TO THE MEMBRANA TYMPANI.

a, Ant. sup. quadrant of membrana tympani; *b*, Ant. inf. quadrant of membrana tympani; *c*, Post. sup. quadrant of membrana tympani; *d*, Post. inf. quadrant of membrana tympani; *e*, Niche of the fenestra rotunda.

(1) The anterior superior segment (*a*) of the inner wall of the cavity, which lies next to the ostium tymp. tubæ, corresponds to the anterior superior quadrant. Only seldom is a portion of the canalis pro. tensor tympani visible.

(2) The ant. infer. segment (*b*) of the internal wall of the cavity next the ostium tubæ, together with a portion of the jagged infer. ant. wall of the cavity, corresponds to the ant. infer. quadrant.

(3) Above the ambos-stapes articulation, behind it the apex of the eminentia stapedia and the tendon of stapedius muscle; below the same the larger and upper portion of the niche of the fenestra rotunda; all these correspond to the post. super. quadrant (*c*).

(4) Above the small lower portion of the niche of the fenestra rotunda, and below a portion of the rough wall of the cavity; these correspond to the post. infer. quadrant (*d*).

The relations as given here of the inner wall of the cavum tympani show many variations which must be borne in mind by ocular inspection or operative procedures. The long process of the incus and its articulation, with the stapes, often lie so low that the greater part of the niche of the fenestra ovalis, with the posterior crura of the stapes and stapedius tendon, is easily visible; in other cases this connection of the incus and stapes is so

* *Realencyclopädie der med. Wissenschaften.* Wien, 1866. Article Gehörorgan.

high that it is completely hid from view by the annulus tympanicus, or only visible by complete destruction of the membrana tympani. The niche of

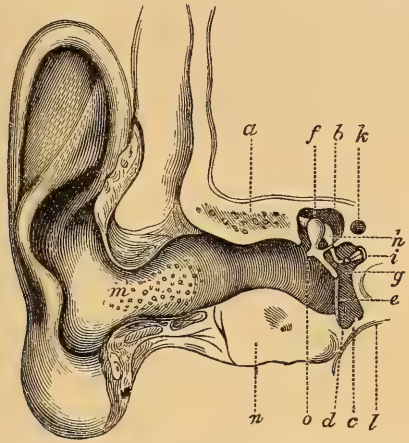

Fig. 57.—Vertical Section of the External Meatus, Membrana Tympani, and Tympanic Cavity.

a, Cellular spaces in the superior wall of the meatus, connected with the middle ear; *b*, Roof of the tympanic cavity; *c*, Inferior wall; *d*, Tympanic cavity; *e*, Membrana tympani; *f*, Head of the malleus; *g*, Handle of the malleus; *h*, Incus; *i*, Stapes; *k*, Canalis Fallopiæ; *l*, Fossa jugularis; *m*, Glandular orifices in the external meatus. (Right ear.)

the fenestra rotunda often is so low that it appears to lie in the region of the post. infer. quadrant only.

Since the membrana is bulged inwards in a funnel-shape, and the inner

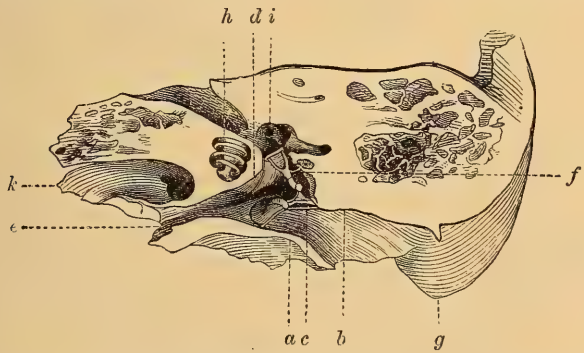

Fig. 58.—Horizontal Section of the Ear.

a, Anterior wall of the osseous meatus; *b*, Its posterior wall; *c*, Section of the membrana tympani, of the handle of the malleus, and of the posterior pouch; *d*, Promontory; *e*, Ostium tymp. tubæ; *f*, Stapes in connection with the inferior extremity of the long process of the incus and of the tendon of the stapedius; *g*, Mastoid process; *h*, Cochlea; *i*, Vestibule; *k*, Carotid canal.

wall of the cavity, on the other hand, is bulging strongly outward, the diameter of the cavity varies very considerably in its different portions.

The clearest conception of the topography of the tympanic cavity is obtained from vertical and horizontal sections (as represented by the accompanying Figs. 57 and 58), or by corrosion preparations.

The distance of the membrane at its umbilical depression from the promontory is on an average 2 mm. Below this spot and at a distance of $1\frac{1}{2}$ mm. is that part of the promontory which is curved most strongly outwards. The distance from this point to the membrana tympani is about $2\frac{1}{2}$ mm.

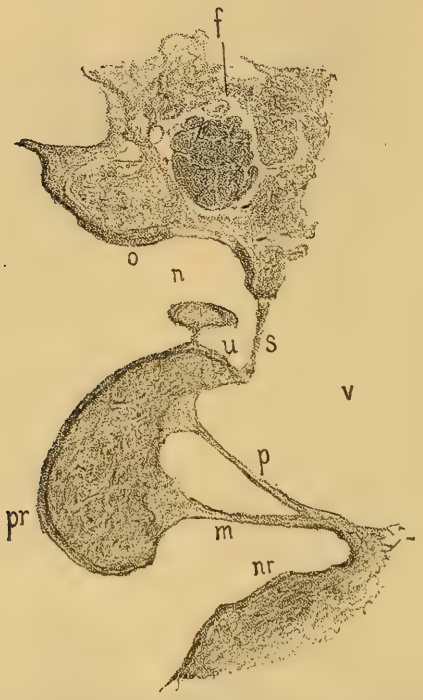

FIG. 59.—FRONTAL SECTION OF THE INNER TYMPANIC WALL THROUGH THE TWO LABYRINTHINE FENESTRÆ.

s, Basis stapedis ; *n*, Niche of the fenestra ovalis with a portion of the crus of the stapes, which has been divided obliquely ; *o*, upper, *u*, lower wall of the niche ; *pr*, Section of the promontory with its mucous covering ; *m*, Membr. fenestræ rotundæ ; *nr*, Niche of the fenestra rotunda ; *p*, Lamina spiralis secundaria ; *f*, Section of the n. facialis ; *v*, Vestibule. After a preparation in my collection.

According to Bezold, the distance of the post. infer. quadrant of the membrane from the inner wall of the cavity varies from 5 to 7 mm ; in the anter. super. quadrant, according to my measurements, from 5 to 6 mm., and in the anter. infer. quadrant from 4 to 5 mm. In the newly-born infant and during the first year the distances are less.

The position of the ossicula and their relation to the walls of the tympanic cavity are rendered clear by Fig. 57. The head of the malleus and the body of the incus lie in a niche-like excavation in the outer wall of the upper

portions of the tympanic cavity. Their immediate vicinity to the exter. super. wall of the cavity facilitates the formation of abnormal adhesions between these ossicula and the walls of the cavity. The stapes, which is nearly at right angles to the malleus and incus, lies with its crura in a small niche in the inner wall of the cavity leading to the fenestra ovalis, which may be compared to a short duct. It then not infrequently happens that both cruræ come into immediate contact with the lower wall of the niche, whereby in cases of inflammation of this region anchylosis of the crura stapedius is favoured.

The topography of the mastoid process has been already given (page 45); the position of the Eustachian tube, more especially that of the ostium pharyng. tubæ, which is so important in catheterization, will be given in the proper section.

PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS.

A. Auricle.

The auricle is of less importance to the functions of the human ear than has been generally supposed by older authors. Each of the depressions of its anterior surface has been supposed to play an important part in the reflection of sound. On the other hand, the auricle has been represented as an accessory formation of no importance to the conduction of sound to the membrana tympani. The latter view has been based upon the fact, that no noticeable disturbance of hearing has been observed in individuals who had lost the auricle from frost-bite or by mechanical injury.

But there can be no doubt that the auricle plays a considerable part in the conduction of sound to the membrana tympani, although not to the same degree in man as in some animals. The concha, that large recess on the auricle already described, is the principal depression on the exterior surface, collecting a portion of the waves of sound that strike the ear, and reflecting them into the meatus. Schneider has proved that a decrease in the power of hearing takes place if this depression is filled up with wax. To test the influence of the auricle upon the reflection of sound, I experimented on individuals who were hard of hearing, because in such persons the distance of hearing for continuous sound is much more sharply defined than in persons whose ears are normal. Now, the head of the patient being placed in a fixed position, and the hearing-distance being ascertained by a metronome, which is then placed somewhat within the boundary of the hearing distance, the sound of the instrument will at once be lost to the patient when the concha is covered by a stiff piece of paper. In this experiment the external orifice

of the ear must remain free. No alteration in the hearing-distance will take place if the other depressions on the auricle are covered.

That the size of the auricle and its angle to the head have an influence upon the reflection of sound into the meatus will be seen from the fact that persons of normal hearing, as well as those who are hard of hearing, will hear more distinctly and more fully, if they bend the auricle forward by pressure upon its posterior surface, or if they augment the surface of the auricle by the hollow of the hand. Therefore, although the loss of the auricle will not have defective hearing as its consequence, the sound will certainly not be perceived so distinctly and fully as if the auricle were in its place.

As the result of examinations made by me, I must consider the tragus of great importance for the reflection of waves of sound which strike the auricle. In front and slightly overlapping the external orifice of the ear, the tragus appears as a nipple-like projection directed backwards, and by this means a considerable space is formed opposite the concha and the orifice of the external meatus. In this space the waves of sound reflected by the auricle (concha) are collected, and are thrown into the external orifice of the ear.

The importance of the space formed by the tragus can be tested by modifying the above-described experiment, by putting cotton-wool steeped in oil into the recess opposite the concha. By this means the sound of the metronome will either be weakened or will totally disappear. On the other hand, the sound will be heard considerably increased if the surface of the tragus is enlarged backwards by placing a small firm plate against it.

It is therefore beyond doubt that the auricle intensifies the perception of sound considerably by reflecting the waves of sound into the external meatus.*

The muscles which are inserted into the cartilage of the ear have only a subordinate influence upon the position of the auricle in man during the act of hearing. On the whole, spontaneous movements of the cartilage of the ear are rare. On the other hand, I observed frequently during the testing of the hearing-distance reflex motions of the auricle, of which the patient knew nothing, and which were visible sometimes in different portions and sometimes over the whole auricle.

B. Conduction of Sound in the External Meatus.

The waves of sound which advance in the column of air in the external meatus are reflected several times by its many curvatures. This refers, however, only to those waves of sound which are reflected into the meatus by the auricle, or which strike the walls

* Küpper, *A. f. O.*, vol. viii., wholly denies that the auricle exerts any influence on the collection and reflection of the waves of sound. Mach holds the auricle for 'resonator for the higher tones, whose working depends partially upon its position against the direction of the waves of sound, modifying the tones so as to assist in locating the direction from whence it comes.'

of the meatus perpendicularly. For waves of sound also reach the membrana tympani, which proceed through the meatus without reflection.

In the reflection of waves of sound from the walls of the meatus upon the membrana tympani, two places in the external meatus must be mentioned as of great importance ; one is the trough-shaped depression on the posterior wall of the cartilaginous meatus, which commences immediately inside the external meatus, and extends along the posterior superior wall to the middle of the canal. It is situated opposite the cavity formed by the tragus, and collects the waves of sound which are thrown back from this place, to reflect them again upon the anterior inferior wall of the osseous meatus.

Here we meet with the concavity, already described, which extends over the inner portion of the anterior and inferior wall of the osseous meatus, and is roofed by the membrana tympani placed obliquely upon the axis of the meatus. This concavity has a parabolical curvature, and the waves of sound which are collected here will strike the membrane very powerfully, as the latter is situated opposite to it.

The waves of sound, however, as is well known, lose their intensity by repeated reflection ; therefore a portion of those entering the ear must be destroyed by the walls of the meatus. It is therefore probable that the sound, which penetrates the ear, strikes the membrana tympani slightly modified in its intensity.

The width of the meatus has only a slight influence upon the intensity of perception of sound, as can be proved by pushing a little ball of wax towards the middle of the canal, so as to diminish its lumen to a small fissure, after having previously exactly fixed the hearing distance for the ticking of a watch. The hearing-distance will be very little altered in this case, and the strength of the ticking will seem hardly diminished. The temperature of the external auditory meatus, according to Mendel (Virchow's 'Archiv,' vol. 50), is about 0·2° C. less than that of the axilla. Eitelberg's measurements gave a difference of from 1° to 0·3° C., but he occasionally found the same temperature as in the axilla. According to the investigations of Claude Bernard, increase of temperature follows section of sympathetic of the neck, and also the facial nerve in both the auricle and external auditory meatus, while by irritation of the facial centre in the medulla oblongata a decrease of temperature results. In acute meningeal affections temperature in the external auditory meatus has been observed 0·1° to 1·0° C. above that of the axilla.

C. Propagation of Sound through the Membrana Tympani, and through the Ossicula.

a. Application of the Results to the Pathology of the Ear.

The membrana tympani, which is set in vibration by the waves of sound which pass through the external meatus, possesses the property of transmitting tones of the most varied duration of vibration,

not only one after the other, but also simultaneously, so as to be uniformly perceptible.*

It must not, however, be looked upon as an elastic membrane ; from the anatomical arrangement of its fibres it is rather a stiff membrane of little elasticity, a quality which is of importance in so far as it prevents after-vibrations, which would impair the distinctness of the perception of sound. In spite of this property the membrana tympani possesses its own tone (E^{iv}), as has been proved by experimental research, but on account of the stiffness of its fibres it is able to tone very little of itself.

The funnel-shaped depression inwards of the membrana tympani produced by the tension of the handle of the malleus, has an important influence on its eminent function.

Helmholtz† has established, upon mathematical and experimental bases, the fact that the power of resonance of curved membranes is incomparably greater than that of flatly stretched membranes. He conducted the tones of a stretched string by means of a wooden pin to a curved membrane stretched across a glass cylinder, and found that its resonance extended over a great part of the scale, and that the curved membrane was also brought into intense vibrations, when high and low tones were produced, by elongating or shortening the string. Mach and Kessel‡ found that the excursions of the posterior segment of the membrane in the living ear are greater than in the other parts, and also that the vibration of the membrane, during the phase of condensation of the waves of sound, travels in a circular manner from the periphery to the centre, while in the phase of rarefaction it travels in the contrary direction.

As has been already said, the membrane, besides its inward curvature, has also a curvature in the opposite direction from the umbo towards the periphery facing the meatus. The radiating fibres, which are stretched out from the periphery to the handle of the malleus, represent a system of stretched strings,§ with the handle of the malleus as its movable bridge. Through the semicircular curvature outwards, the radiating fibres offer a favourable point of contact for the waves of sound to strike the membrane, as Helmholtz asserts. My investigations in this direction show, however, that the increase and transmission of the sound is the same whether the membrane is concave or convex on the surface upon which the sound strikes. Helmholtz has further proved that only a slight motion of the point of the handle of the malleus takes place, in proportion to a relatively great excursion of the membrane, and that, on the other hand, the membrane executes a great excursion with only slight motions of the handle of the malleus.

* That the artificial membrane is able by the proper adjustment to transmit the complicated combinations of sound waves is proved by the Edison phonograph.

† *Die Mechanik der Gehörknöchelchen und des Trommelfells.* Pflüger's *Archiv*, vol. i.

‡ *Beiträge zur Topographie und Mechanik des Mittelohres. Reports of Vienna Acad. Session*, April, 1874.

§ This statement was first made by me, and was repeated lately by Fick (*A. f. O.*).

Fick asserts that, in consequence of the oblique plane of the membrana tympani, the waves of sound strike the ear in a less favourable manner than if the membrane were placed perpendicularly upon the axis of the meatus. As, however, the waves of sound advance with a spherical wave-front, and on the other hand the membrane is also curved, great importance must by no means be attached to the inclination of the membrane as regards the reception of the waves of sound.

Transmission of Sound from the Membrana Tympani to the Labyrinth.—The vibrations of the membrana tympani are partly transmitted to the labyrinth by means of the ossicles and foot-plate of the stapes, and partly through the air of the cavum tympani acting on the fenestra ovalis.

While the older physiologists, especially Pascal and, at a more recent date, Sapolini and Pecchi (*Il sordo muto*, Nov. 5, 1890), contended that the principal means of sound transmission was by means of the fenestra ovalis, physiological investigation and pathological-anatomical examination go to prove that the chain of ossicles are the principal method of sound transmission from the membrana tympani to the labyrinth.

The ossicula form a system of sensitive levers, through which the vibrations of the membrana tympani are transmitted to the labyrinth. The disputed position as to whether in the transmission of sound through the ossicular chain only a mutual movement of the separate molecules of the ossicula towards each other takes place, or whether the separate portions of the chain, malleus, incus, and stapes vibrate as whole bodies with extensive oscillations, could only be determined by means of direct experiments in the auditory organ.

By means of a series of experiments conducted by me in the year 1861 (*Arch. f. O.*, vol. i.), I was the first to furnish experimental proof that the ossicula vibrate as whole bodies, with extensive amplitudes under the influence of the waves of sound which strike the membrana tympani.

After removal of the tegmen tympani and of the inner or labyrinthine wall, fine threads of glass, 10-12 cm. in length, with the fibre of a feather attached to their point, were fastened by means of resin one after the other to the malleus, incus and the foot-plate of the stapes, and the tones of organ-pipes of different height were conducted through the external meatus to the membrana tympani.

The vibrations of the ossicula were rendered considerably more perceptible by the sensitive glass levers which were fastened to them, and were plainly visible to the naked eye. The vibrations may, however, be most distinctly traced if the ossicula are made to register them themselves. For this purpose a brass drum is used, which revolves round its longitudinal axis and moves forward, is covered with paper and blackened by the smoke of a turpentine lamp. If the point of the vibrating thread of glass is brought into contact with the blackened surface of the cylinder quickly rotating, regular spiral lines will be produced upon it.

These experiments have been made with simple and compound notes.

With simple notes regular spiral lines were traced (Fig. 60, 1); with compound notes, however, vibrations were created by the interference of the waves of sound, which were visible upon the surface of the cylinder as regularly recurring straight-lined places between the spiral lines (Fig. 60, 2). The most regular drawing of this interference was obtained by the notes of two organ-pipes, which were exactly an octave apart; in each great spiral curve of the deeper octave, the smaller curve of the higher octave was inserted (Fig. 60, 3).

The proportion of the vibration of the ossicula depends principally on the mechanism of the joints. In 1862, I discovered by experiment (*Wiener Med. Wochenschrift*, Nos. 13 and 14) that every time the air is condensed in the tympanic cavity, a considerable excursion of the membrana tympani with the handle of the malleus outwards towards the meatus, and a distinct motion of the articular surfaces of the malleus and incus, are visible, while the excursions of the long process of the incus are very trifling. This is

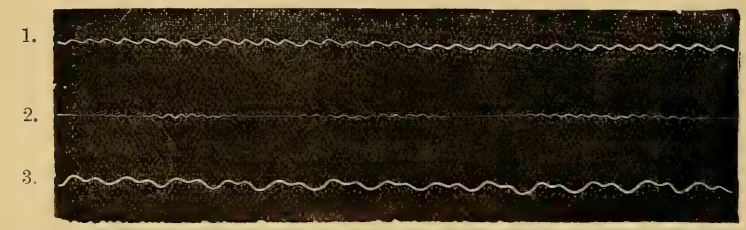

FIG. 60.—SELF-REGISTERED TRACINGS OF THE VIBRATIONS OF THE OSSICULA.

plainly a foreshadowing of Helmholtz's very recent description of the mechanism of the articulation of the malleus and incus. As already mentioned, he compares that articulation with the mechanism of the catch-contrivance inside a watch-key. With the excursion inwards, the cog of the malleus catches exactly in that of the body of the incus, causing the latter bone to follow the motion. With the motion outwards, however, the cog of the malleus unhooks itself from that of the incus, and the malleus principally is moved outwards, the incus being so only in slight degree.

The relative range of the motion of the separate bones may be ascertained by the method indicated by me, in the following manner. Threads of glass of equal length are fastened to the malleus, incus and stapes, and the membrana tympani is brought into motion by condensation and rarefaction of air in the external meatus. It will then be seen that the sensitive glass lever on the malleus executes much greater excursions than that on the incus, and that the excursions of the thread of glass fastened to the stapes are the slightest. By the same method I have also proved* that the axes of the ossicula are not fixed, but movable; and I have made the statement, that in transmitting the waves of sound from the membrana tympani to the labyrinth, the vibrations of the malleus are greater than those of the incus, while those of the latter are again greater than those of the stapes.

* *Wochenblatt der Gesellschaft der Aerzte*, No. viii., 1868.

These assertions have been confirmed by Schmiedekam.* Dr. Buck of New York afterwards made use of another method to trace the vibrations of the ossicula. It is on the principle of Lissajous, based upon the optical examination of the vibration of bodies.† Buck fastened starch granules to the ossicula, and examined their vibrations by means of a microscope supplied with a micrometer. The starch corpuscle, which was fixed under the microscope, and which appeared as a whitish spot when at rest, expanded during the vibration of the membrana tympani and the ossicula into a line, the length of which for each of the bones could be measured by the micrometer. Buck has proved by this method, which has the advantage that the ossicula are not weighted during the experiment, that the vibrations of the malleus are twice as strong as those of the incus, and four times as strong as those of the stapes. The greatest excursions take place at the tip of the handle of the malleus, 0·76 mm.; those of the long process of the incus, 0·21 mm. According to Helmholtz, the greatest excursions of the stapes amount to $\frac{1}{18} - \frac{1}{14}$ mm. These measurements are, however, only to be assumed in the case of extensive excursions of the ossicula, when they are brought into motion by alternate condensation and rarefaction of the air in the external meatus or in the tympanic cavity. During vibrations caused by sound, however, the excursions of the stapes are very trifling, and Riemann correctly remarks, that with weak, but still plainly perceptible notes, they must be so slight as not to be discernible even with the most powerful microscope.

The motion in the sound-conducting apparatus is compared by Helmholtz to that of an unequal lever, which executes great excursions at one side, and small ones at the other. If, according to the foregoing, the excursion of the vibrations is decreased as the waves of sound progress through the ossicula owing to the bulging in the membrana tympani, their intensity is by no means lessened.

By the mode of articulation of the malleus and the incus, the organ of hearing is protected from violent concussions acting upon the membrana tympani. When, by a sudden condensation of the column of air in the meatus, the membrane with the whole ossicular chain is rapidly forced inwards, the violent shock which would fall upon the labyrinth is prevented by the outwardly convex arches formed by its radiate fibres, stretched between its two end points, the annulus tympanicus and handle of the hammer. For the shock falling upon the convexity of these arches serves to straighten them, and in this way the handle of the malleus is arrested in its excursion inwards, before it has exerted much force on the incus.

The labyrinth is also protected against excessive variations of pressure, due to the sudden entrance of air into the tympanum, because, as already

* *Experimentelle Studien zur Physiologie des Gehörorgans.* Inaugural Dissertation. Kiel, 1868.

† Mach and Kessel (*l. c.*) made use of the same method to ascertain the axes of the ossicula during vibrations caused by the sound. They found that the stapes performed no piston-like motion in the fenestra ovalis, but that it revolved round an axis situated near the inferior margin of the foot-plate of the stapes, so that the superior margin penetrates deeper towards the vestibule than the inferior margin.

mentioned, the membrana tympani with the handle of the malleus is moved outwards to a considerable extent, while the incus and the stapes follow this motion only in a slight degree.

The resistance to the vibration of the ossicula is caused partly by their articular ligaments, partly by the fibrous ligaments and folds of mucous membrane which extend from the walls of the tympanic cavity to them. These obstacles are of the greatest importance in favouring the uniform reception and conduction of the waves of sound, which vary in the duration of their vibration (Riemann, Helmholtz). They give the ossicular chain a sufficient amount of stability, by which the necessary proportion between the tension of the membrana tympani and that of the ossicula is effected.

Application of the Results to the Pathology of the Ear.—The anomalies which arise between the tension of the membrana tympani and that of the ossicula owing to pathological changes must impair the propagation of sound. In cases of closure of the Eustachian tube an increased tension of the membrana tympani arises by rarefaction of air in the tympanic cavity, which will be followed by increased tension of the ossicula. The result of this is an abnormal increase in the obstacles and a hindrance in the conduction of sound to the labyrinth. Cases will also occur where the membrana tympani gets thinned and atrophied—from excessive pressure—on one side for a long time, or by extensive cicatricial formation, whereby it loses its normal degree of tension. Here also the anomaly between the tension of the membrane and that of the ossicula will cause a disturbance of the functions. This also holds good with regard to those pathological processes in the middle ear, where the tension of the membrana tympani is not altered, but where obstacles are created by diseased products at the joints of the ossicula, or in places where they come in contact with the walls of the tympanic cavity, which produce a hindrance to the conduction of sound.

The principle of Lissajous, made use of by Buck, I have applied in a number of experiments, the results of which are of importance in the explanation of functional disturbances, observed in consequence of pathological obstacles to the conduction of sound in the middle ear. As a point on the ossicula, if fixed by a microscope, appears as a line during their vibration, the intensity of the vibrations was measured during these experiments by the alteration in the length of this line. The results of these experiments, published by me in 1871 (*A. f. O.*, vol. vi.), are as follows :

1. If the tones of a harmonium are conducted by means of a tube to the membrana tympani of an anatomical preparation of the ear, it is found, that with equally intense tones the intensity of the vibrations of the ossicula is less with deep tones than with high ones above the middle range, while with very high tones the intensity decreases again.

2. If words are spoken into the meatus through a hearing-trumpet, the ossicula exhibit as many oscillations as there are syllables in the word. The greatest excursion of the oscillation coincides with the vowel of the syllable.

3. If some portions of the membrana tympani are weighted with a small ball of wax or a little rod, the intensity of the vibrations of the ossicula decreases only in a slight degree ; but if the malleus or other ossiculum is weighted in the same manner, and an obstacle to the conduction of sound is thereby created, similar to the exudations and adhesions which have arisen from disease of the middle ear, the excursion of the vibration is considerably diminished.

4. If deep or high tones act upon the membrana tympani while the ossicula are weighted as above, a comparatively greater vibration will be observed with high than with deep tones. The vibrations will also be notably less during the speaking of words into the meatus, than during the impact of musical tones.

These results agree with the disturbances of hearing observed in patients. Alterations on the membrana tympani, as cicatrices, calcifications and perforations, will impair the power of hearing less than pathological products (adhesions, anchylosis) in the ossicula, which diminish their power of vibration. It will also be seen, that in such cases high tones are mostly heard better than deep ones, and that the perception of speech is more affected than that of musical tones.

5. If the membrane is artificially destroyed, the vibrations of the malleus become less ; but if an artificial membrana tympani is inserted, and its india-rubber plate is brought into contact with the handle of the malleus, the vibrations will again become stronger.

6. The jingling sounds in the ear, observed by Helmholtz after intense concussions, are in my opinion not caused by the striking against each other of the cogs of the articulation of the malleus and the incus, but, as my experiments have shown, by the whizzing of the membranes and ligaments of the ossicula ; for these jingling tones can be produced in the ear of a dead body by the tone of an organ-pipe, even if the articulation of the malleus and the incus has been artificially anchylosed.

D. Physiology of the Eustachian Tube.

It is well known that when the mouth and the nose are closed, air can be forced into the tympanic cavity by means of a powerful act of expiration, by which the membrana tympani will be somewhat forced outwards. This is called the Valsalvian experiment. By the condensation of air in the tympanic cavity, which results from this experiment, a sensation of fulness and tingling in the ear, and a slight degree of hardness of hearing, especially for deep tones, are brought about.

A similar sensation will be perceived if the act of swallowing is performed when the mouth and nose are closed. But in this case

the air in the tympanic cavity is not condensed (Toynbee), but, as I was the first to prove, rarefied, as part of the air in the pharynx is swallowed, and the rarefaction of air extends from the pharynx through the tube to the tympanic cavity.

If the nasal orifices are opened again after the act of swallowing, the sensation of tension in the ear nevertheless remains; it will only disappear when the act of swallowing is repeated with the nasal orifices unclosed.

This can be simply explained. The Eustachian tube is opened wide, during the act of swallowing, by the action of its muscles, and the rarefaction of air arising in the pharynx extends to the tympanic cavity. Immediately after the act of swallowing, however, the walls of the tube lie again close together, and the air in the tympanic cavity remains rarefied, while the atmospheric pressure again prevails in the pharynx. As there is now a difference in the pressure of air in the tympanic cavity and in the pharynx, the membranous wall of the tube is pressed closer to the cartilaginous wall by means of the external pressure of air, so that the closure of the Eustachian tube is more complete than it is in ordinary circumstances. If now another act of swallowing be performed, the tube will again be opened, and the pressure of air in the tympanic cavity and in the pharynx will be equalized.

These results followed from a number of experiments performed by me, in 1860, in the laboratory of C. Ludwig. I made use of a small glass tube, 2-3 mm. wide, fitted into an india-rubber stopper (ear-manometer, Fig. 61), and furnished with a drop of coloured fluid. This tube was hermetically sealed into the external meatus. During the Valsalvian experiment, the fluid in the manometer was seen to rise. If an act of swallowing were performed with the closed mouth and nose, during the first stage of this act a slight rise (positive fluctuation) of the fluid in the manometer took place, followed, however, during the second stage of the act of deglutition, by a considerable fall (negative fluctuation), as the air in the tympanic cavity is rarefied and the membrana tympani is pressed inwards. The fluid will now remain in the place where it fell to after the act of swallowing, and will return to its former place only when the closed Eustachian tube is reopened by another act of swallowing with open nostrils. In many cases, and even in the same individual, slight fluctuations of the fluid in the manometer will be observed even with quiet respiration, corresponding with the respiratory movements; these fluctuations will be greater the more quickly the air is allowed to pass through the nose, and when a greater obstacle is presented to the passage of air by closure of one of the nostrils.

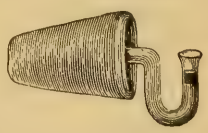

FIG. 61.—EAR-MANOMETER.

The opening of the Eustachian tube during the act of swallowing can also

be proved by another simple experiment, which was first performed by me in 1869. If a vibrating tuning-fork is held in front of the nostrils, a uniformly weak sound will be heard in both ears; during an act of swallowing, however, the tone of the tuning-fork will be perceived in both ears greatly increased, as its vibrations penetrate unchecked into the tympanic cavity through the open Eustachian tube.

It has already been pointed out, that the surfaces of the mucous membrane in the middle portion of the Eustachian tube come into contact with each other on all sides. This portion of the cartilaginous tube is sometimes large and sometimes very short, as I have observed in a number of preparations, which explains the normal individual differences observed in regard to the amount of hindrance to the passage of air along the tube from the pharynx.

The oft-discussed question, whether we can hear through the Eustachian tube, and especially whether we can understand speech, when the conduction of sound by means of the external meatus and the membrana tympani is excluded, will be decided in a positive manner by the following experiment. An individual of normal hearing, whose meatuses are so firmly closed by means of the moistened fingers that he cannot understand speech at a distance of one meter, has the ear-piece of a hearing trumpet of the same length inserted into the orifice of the nose, and the nostrils are closed round it by another person. The person experimented on will now at once distinctly hear speech, which he could not understand before, if it is spoken into the hearing-trumpet. That many persons can understand whispered speech, while others only understand loud speech during this experiment, is due to the fact that the walls of the Eustachian tube vary individually, in respect to the closeness with which they are applied to each other. But from this fact the conclusion can by no means be drawn that the tube is open, as speech can also be understood through an india-rubber tube, the walls of which lie loosely together for a short distance.

These anatomical observations and experiments give the following results:

1. The Eustachian tube is not constantly gaping; its permeability varies individually, as in a number of cases a current of air from the pharynx towards the tympanic cavity takes place even during quiet respiration, while in other cases an act of deglutition, or a powerful expiration with opened or closed nostrils, is necessary to make the tube passable for the current of air.*

2. The Eustachian tube is opened during the act of swallowing chiefly by the action of its muscles, especially the abductor tubæ (v. Tröltsch),† as is proved by the experiments of Toynbee ‡ and myself.

* Confirmed by Mach and Kessel: *Die Function der Trommelhöhle und der Tuba Eustachii, Vienna Acad. Reports*, 1872.

† During experiments on vivisected dogs I succeeded in observing a widening of the fissure of the tube in the wall of the pharynx by the irritation of the trigeminus in the cranial cavity. The dissection showed that the widening was caused by the tensor palat. moll. *Ueber eine Berziehung des Trigeminus zur Eust. Ohrtrompete. Würzburger naturwissenschaftliche Zeitschrift*, 1861.

‡ *Diseases of the Ear*, 1860.

3. When the air-pressure in the tympanum exceeds that in the pharynx, or *vice versâ*, equalization of the pressure will be brought about by the passage of air from the one cavity to the other ; but the passage of air from the former to the latter takes place more readily than from the latter to the former.

E. Application to the Pathology of the Ear.

In regard to the pathology of the ear, the following considerations result from the above physiological facts :

1. The permeability of the Eustachian tube is of great importance for the function of the organ of hearing. If the tube become impermeable by swelling of the mucous membrane, or by accumulation of secretion, the consequences of the interruption to the exchange of air between the external atmosphere and the tympanic cavity will shortly become apparent. By exclusion of the air from the tympanum, and consequent rarefaction of the air in that cavity, congestion of its tissues and exudation into it will often follow. As the external pressure of air preponderates, the membrana tympani and the ossicular chain become tensely stretched and forced inwards by it, and are partially deprived of their power of vibration.

2. By the opening of the Eustachian tube during the act of swallowing, the resistance which is opposed to the current of air from the pharynx to the tympanic cavity is considerably lessened. Where it is necessary, therefore, in disease of the middle ear, to render the tube permeable, and to employ the action of a strong current of air in the tympanic cavity, the effect will be materially increased if, during the inflation, an act of swallowing is performed.

F. On the Influence of the Variations of the Air-pressure in the Tympanic Cavity upon the Tension of the Contents of the Labyrinth.

The sensation of fulness or tension in the ear, accompanied by a tingling and slight degree of hardness of hearing, which arises from condensation or rarefaction of the air in the tympanic cavity, has, since the time of J. Müller, been attributed to altered tension of the membrana tympani. In the explanation, however, the pressure upon the elastic membrane of the fenestra rotunda, and upon the foot-plate of the stapes with the membrane bordering on it, and consequently upon the whole contents of the labyrinth, remained totally disregarded.

To prove that, as I supposed, an alteration in the amount of tension of the contents of the labyrinth would take place with increased or decreased

pressure in the tympanic cavity, I instituted a number of manometrical experiments on fresh human ears (in Prof. Ludwig's laboratory), during which the condensation and rarefaction of air in the tympanic cavity were produced by an air-pump (Fig. 62) connected with the Eustachian tube (*c*). A manometrical tube, partly filled with a solution of carmine (*h*), was introduced into the opened superior semicircular canal, and fastened hermetically. Now, when the air in the tympanic cavity was condensed by compression of the balloon, an outward curvature of the membrana tympani and also a rising of the fluid in the manometrical tube in the labyrinth (*h*)—positive fluctuation of $1\frac{1}{2}$-3 mm.—were observed, while during rarefaction a distinct fall of the fluid in the manometer was noticed. If the fenestra rotunda is closed by wax, a decrease in the fluctuation of the fluid in the manometrical tube will take place during condensation of air in the tympanic

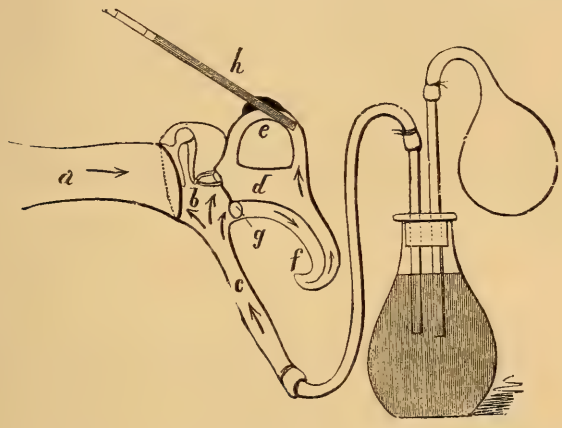

FIG. 62.

a, External meatus; *b*, Tympanic cavity; *c*, Eustachian tube; *d*, Vestibule of the labyrinth; *e*, The superior semicircular canal with the manometrical tube introduced into it; *f*, The cochlea with the scala vestibuli and tympani; *g*, Fenestra rotunda.

cavity. If the articulation of the stapes and incus is severed, an increase in the fluctuation of the fluid to the extent of $\frac{1}{2}$-$1\frac{1}{2}$ mm. results in consequence of the resistance, which was formerly opposed to the motion inwards of the stapes being removed.

Bezold, whose manometrical experiments led to similar results, found on testing the membrane of the fenestra rotunda alone that it was capable of an excursion of more than $\frac{1}{3}$ mm., while that of the foot-plate of the stapes did not exceed $\frac{1}{16}$ mm. The possible extent of the excursions of the membrana fenestra rotunda is thus five times greater than that of the foot-plate of the stapes.

From these experiments it is shown:

1. That by condensation of air in the tympanic cavity, not only does an alteration in the tension of the membrana tympani take place, but by simultaneous action on the membrane of the fenestra rotunda and on the

movable foot-plate of the stapes, the pressure on the contents of the labyrinth is considerably increased. The extremities of the auditory nerve, surrounded by the auditory fluid, are mechanically irritated by this increased pressure, which will cause subjective sensations of sound. The slight degree of hardness of hearing can be explained in a similar manner to the disappearance of the perception of light when a moderate pressure is exerted by the finger on the eyeball. The fact that in this case hardness of hearing for deep tones especially occurs, while high tones can still be heard comparatively well, has to be attributed to the altered tension of the membrana tympani; but it must not be lost sight of, that at the same time also the structures of the labyrinth (lamina spiralis membranacea and membranous saccules) are more tightly stretched, and that they will vibrate with greater difficulty in response to deep tones.

2. In the above experiment an explanation is to be found for the subjective noises and disturbances of the function of hearing, so often accompanying those diseases of the ear in which, by accumulation of serous or mucous exudations, or by the new formation of connective tissue in the tympanic cavity, the two fenestræ of the labyrinth are abnormally weighted, or in which the membrana tympani and the ossicula are pressed inwards, the tension in the labyrinth being abnormally increased by the excessive pressure of the foot-plate of the stapes.

G. Function of the Intra-tympanic Muscles.

Our knowledge hitherto concerning the action of the intra-tympanic muscles relates to the mechanism of the increase and decrease in the tension of the membrana tympani, and also to the regulation of the intra-tympanic pressure. In what manner they take part in the act of hearing has not been proved. Concerning the influence of the tension of the membrana tympani upon the perception of tones, I have proved (*A. f. O.*, vol. i.) by experiments on human ears, as well as on preparations of the same organs from dogs, which had just been killed, in which the tensor was made to contract by electrical irritation of the trigeminus in the cranial cavity, that, especially during testing with deep tones (tuning-forks), a softening down of the key-note and a greater distinctness of the upper notes is observable.

Hansen and Bockendahl,* who opened the cavum tympani of dogs and attached a light, sensitive lever to the tendon of the tensor tympani muscles, observed a reflex contraction of that muscle on sounding musical notes. J. Pollak,† who substantiated these results, found that the energy of the contractions was, as a rule, greater for high than for deep notes, was strongest for the vowel *a*, very slight for *u*, and further, that by the action of musical

* *Arch. f. Ohrenheilk.*, vol. xvi.
† *Med. Jahrbücher*, Wien, 1886.

notes on the one ear a reflex contraction of the muscle of the other could be brought about. Destruction of both labyrinths is accompanied by complete disappearance of the reaction of both tensor tympani muscles.

I have experimentally proved that the action of the tensor is not confined alone to the membrana tympani, but that it extends also to the labyrinth, as I observed a motion of the fluid in the labyrinth on electrical irritation of the trigeminus in the cranial cavity. The tensor tympani increases, therefore, the pressure in the labyrinth.

Recently, Dr. Secchi, docent at Bologna, has experimentally proved on dogs and cats, by means of a manometer tube hermetically placed in the osseous bulla: 1. That the pressure of air in the cavum tympani, through the action of the muscles of the tube or in connection with the intrinsic muscles of the ear, is higher than the external atmospheric pressure. 2. That the intra-tympanic air-pressure is increased by tones or noises, on account of the contraction of the tensor tympani muscle. 3. That the stapedius muscle is to be considered an antagonist to the tensor tympani, for it relaxes the membrana tympani and lessens the pressure in the labyrinth, as Politzer first experimentally proved by irritation of facial nerve in the cranium (*Wiener Medicinalhalle*, 1867).

From examinations conducted hitherto, we can at present only state that it is one of the principal functions of the intra-tympanic muscles to remove the alterations in the position and tension of the ossicular chain and of the contents of the labyrinth, which are caused by the variable fluctuations in the air-pressure, in fact, to regulate the degree of tension of the hearing-apparatus.

I was the first to state the view, upon the basis of observations on myself and on aural patients (*A. f. O.*, vol. iv.), that the deafness which occurs during yawning is brought about by a simultaneous motion of the tensor tympani. This view was confirmed by Helmholtz (*l. c.*).

Concerning the spontaneous contractions of the tensor tympani, Luschka and I advanced at the same time the opinion, that the cracking noises in the ear, which many persons can cause spontaneously, arise from the contraction of the abductor tubæ. The observations of spontaneous contractions of the tensor tympani have only rarely been made (Schwartze, *A. f. O.*, vol. ii.; and Lucæ, *ibid.*, vol. iii.). In a case described by me (*A. f. O.*, vol. iv.), involuntary as well as spontaneous contractions of the tensor were observed in both ears.

Lucæ first observed that by contraction of isolated muscles of the face, most easily by the musculus orbicularis, a simultaneous contraction of the stapedius can be produced. This produces a deep humming sound in the ear and also a relaxation of the tympanic membrane, as is shown by the manometer. During such reflex contractions the perception of the deeper and middle tones of the tuning-fork is destroyed.

II. THE METHODS OF PHYSICAL EXAMINATION OF THE ORGAN OF HEARING.

A. The Examination of the External Meatus and Membrana Tympani.

Examination of the external meatus and of the membrana tympani is indispensable to the knowledge of pathological changes in the organ of hearing. The membrana tympani, being covered on the outside by the cutis of the external meatus, and on the inside by the mucous membrane of the tympanic cavity, is in intimate relation to the affections both of the external meatus and of the middle ear. The processes of disease going on in them cause changes in the membrana tympani, which may be recognised by ocular inspection, and enable conclusions to be drawn as to the pathological state of the external and middle ear. Experience shows that the diseases of the middle ear most frequently form the basis of functional disturbance in this organ, and since these affections are often combined with changes in the membrana tympani, it will be seen that the state of the latter is of great importance in the diagnosis of affections of the former.

It must, however, be distinctly noted, that alterations in the membrana tympani are observed in a considerable number of persons of normal hearing, without the least disturbance of function. These alterations are to be considered as inherent anomalies, or as the residue of some pathological process which has ended in complete cure. On the other hand, the membrana tympani is perfectly normal in a considerable number of persons whose hearing is disordered to a high degree. In spite of the diagnostic importance of the conditions observed in the membrana tympani we are never able to draw any conclusion from them as to the degree of functional disturbance, for experience has shown that extensive perforations, cicatrices, and calcifications are often accompanied by only a trifling disturbance in hearing; while, on the other hand, with only slight deviations from the anatomically normal state a high degree of deafness is often observed.

As already mentioned, disturbances of the function in the case of diseases of the middle ear are most frequently caused by those products of disease which diminish the mobility and power of vibration of the ossicula.

Ear Specula.—The most practical method of examination which is now in actual use is v. Tröltsch's method with the conical speculum and concave mirror. The bivalve form called Itard's or Kramer's speculum, formerly used, has justly been laid aside on account of its defectiveness in comparison with the more recent and more reliable instruments.

The conical specula, first used by Deleau and Ignaz Gruber, and modified in shape and size by Arlt, Toynbee, Wilde (Fig. 63), and Ehrhard (Fig. 64), consist of metal, with a polished or blackened interior. They are either funnel-shaped or like a truncated cone, and have a round or oval aperture at their extremity ; but this, as well as the shape of the speculum, is of little importance.

The vulcanite specula (Fig. 65), which I brought into practice, have the advantage of being considerably lighter than those of metal, so that they remain in the required position, and also of not producing the unpleasant chilly sensation of the polished metal speculum. Their black interior serves to render the surface of the membrane more distinct by contrast, and with

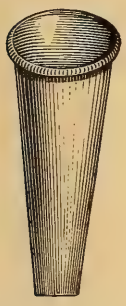

Fig. 63.—Wilde's Speculum.

Fig. 64.—Ehrhard's Speculum.

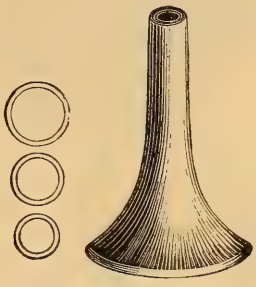

Fig. 65.—The Author's Speculum of Vulcanite.

judicious illumination the view of the membrane will therefore appear clearer than with the same light reflected from a polished metal speculum.

The different sizes, 8, 6, 4, and 2 mm. in diameter at the aperture (Fig. 65), are constructed to suit various meatuses.

Reflector.—These specula, combined with a reflecting concave mirror perforated in the centre, 7-8 cm. in diameter and of 10-15 cm. focal distance, allow, with sufficient light, an accurate view to be obtained of such pathological changes as are perceptible in the membrane or meatus.

For operations on the ear, when both hands are required for manipulation, the mirror should be fixed to the head by Semeleder's head-band, to which it is fastened by means of a ball-and-socket joint in front of the eye of the observer. Each mirror can be so constructed as to be used with a handle as well as a head-band. In my practice I use a mirror fixed to the head by a strong half-circle made of spring steel, and striking the forehead and occiput. Schwartze and Trautmann use no special fixation apparatus while operating, but direct the mirror with the thumb of the left hand on which it is fastened by a movable ring.

Refractive anomalies of the eye, which sometimes occur, often necessitate the application of corrective lenses to obtain a distinct view of the membrana tympani. Persons of normal sight or short-sighted to a moderate degree do not require these lenses. But persons with presbyopia or hypermetropia must positively use convex lenses, as most of them can see the membrane only very indistinctly without a corrective lens, while with one suitable to the degree of the refractive anomaly they not only see the membrane distinctly, but also somewhat magnified. These lenses are best fixed by means of a semicircle of vulcanite placed at the back of the mirror and furnished with a groove for the reception of the correcting lens, and capable of being removed from the aperture of the mirror by means of a joint fixed to the upper extremity of the handle (Fig. 67).

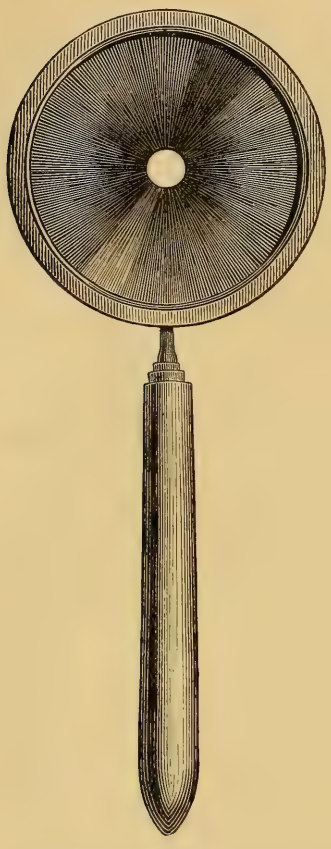

Fig. 66.—Concave Mirror perforated in the Centre, with Handle (half Size).

For the production of a magnified image of the membrana tympani bi-convex lenses are used, which by means of a simple contrivance, designed by Dr. Auerbach of Hamburg, are fixed obliquely at the entrance of the speculum. Moderate enlargements can also be obtained by convex lenses of greater focal distance, which are fixed as above on the posterior surface of the mirror. By magnifying the membrana tympani many changes, especially vascular ramifications, small deposits, projections and depressions, movable exudation and air-bubbles in the tympanic cavity, come distinctly into view. Such enlargements are of value chiefly to persons with hypermetropia or presbyopia, while short-sighted people can do without them.

Brunton's otoscope, in which the speculum, reflector, and magnifying lens are combined in one piece, is so unmanageable that it cannot be recommended to the practitioner. Weber-Liel's 'ear microscope' and Voltolini's 'ear lens' have been determined useless.

The illumination of the membrana tympani is effected either by ordinary daylight or by artificial light. The latter should be used

in badly-lighted houses, on dull days, and at the bedside when the natural light is insufficient. It is best to use either gas or a petroleum lamp, although candle-light may be used for want of a better. An intense light is given by the Auer's gas-light, which consists of a network cylinder impregnated with certain metal salts and is made to glow by means of a Bunsen burner. The effect of petroleum and gas-light can be considerably intensified by the use of convex lenses and reflecting mirrors. The examination with compound lenses has the disadvantage of tiring the eyes by long use. Artificial light has a farther disadvantage that the colour of the membrane is more or less altered by it.

The electric light, the use of which has recently been recommended, possesses no important advantages over that obtained from a good gas or petroleum light. That form of electric apparatus most frequently used consists of an incandescent lamp, which is worked by a pocket battery, and attached to the forehead, throws a beam of light directly into the meatus. The form suggested by Claar, with an incandescent lamp fastened upon a reflector, serves the same purpose.

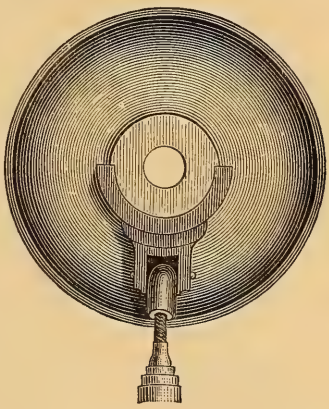

Fig. 67.—Posterior View of the Concave Mirror with Contrivance for the Reception of a Corrective Lens (half Size).

As a rule, however, ordinary daylight, by means of which the shades of colour of the membrane are perceived in the most natural manner, is preferable, on account of its simplicity, to all other methods of illumination. This is especially the case with diffuse daylight taken directly from a cloud, or sunlight reflected on to the mirror from a bright wall, that from a blue sky being too dull. Artificial illumination is, however, preferable in dull weather. Illumination by direct sunlight, which, according to Lucæ can be managed with a plane mirror, is of use in demonstrating exudations in the tympanic cavity, and for the clearer appreciation of the vascular ramifications and other minute changes in the membrana tympani. When using diffuse daylight in brilliant sunny days, it is well to follow Wintrich's advice and admit the light through a moderately large opening in the closed shutters.

Method of Otoscopy.—During the examination the head of the patient must be placed so that the ear to be examined is turned away from the light, and the rays which fall on the concave mirror at an angle of 45° may be reflected directly into the lumen of the external meatus, otherwise the head of the patient would prevent a portion of the rays from reaching the mirror.

To insert the speculum into the meatus, it is necessary with the left fore and middle fingers to draw the auricle a little backwards, upwards, and also towards the observer, so that the axes of the osseous and cartilaginous portions of the meatus, which form an angle in their natural position, are brought into a straight line, thus rendering a free view of the membrana tympani possible.

Then the speculum, slightly warmed, is inserted into the cartilaginous meatus with a slight rotatory movement by means of the thumb and forefinger of the right hand, far enough so that the hairs which obstruct the view are completely turned aside. The introduction of the speculum, especially in the case of older persons, often causes a troublesome reflex cough, brought about by irritation of the auricular branch of the vagus. Fainting fits and epileptiform convulsions are more rare, though they occasionally occur. If the instrument has penetrated to the osseous meatus, which can easily be noticed by the slight resistance, any attempt to push it farther must be avoided, owing to the violent pain caused by pressure upon the nerves of this part. The mirror, held in the right hand, slightly reclining on the glabella, is brought near the ear, so that the rays of light, reflected through the speculum, are focussed at the membrana tympani. Care must be taken that the eye which is behind the central opening in the mirror is in the line of the axis of the speculum opening, and the practitioner should accustom himself always to examine with that eye before which the mirror is placed, both eyes being kept open all the time as in microscopy. It is, however, seldom possible to view the meatus and the membrana tympani at once; to view their separate portions one after the other it is therefore necessary to move the speculum as well as the mirror in all directions with the unoccupied thumb, which the observer's eye must also follow through the central aperture.

In spite of the exact observance of these instructions, we get only an imperfect view of the membrane in some cases, in consequence of various obstructions which occur, sometimes in the cartilaginous, sometimes in the osseous meatus. Among these obstructions may be mentioned: an abundant growth of hair extending into the osseous meatus, collections of cerumen, which, either in the form of plugs or deposits on the walls, obstruct or narrow the meatus, epidermis scales, which, either as white or mother-of-pearl-like membranes and strings, are stretched across the passage. Large quantities of cerumen and detritus are best removed by soaking and syringing, but smaller portions, such as are adherent to the walls, may be removed by means of the vulcanite ear scoop, fatty deposits by a plug of wool. Small ceruminal particles, detached epidermis scales, and membranes are best removed with my forceps (Fig. 68), which have narrow, spoon-shaped extremities and cross blades, and which possess the advantage that

the opening of the blades in the meatus is less interfered with by the speculum than in forceps without crossed blades. For the extraction of small particles lying deep in the canal, the Sexton pincette is best adapted. (*v.* 'Extraction of the Hammer and Incus.')

More important, because their removal is impossible, are the hindrances to examination which arise from inherent narrowness of the meatus, or from the abnormal bulging of the anterior inferior wall of the osseous portion. This constriction has as its consequence an insufficient illumination of the range of view, while the more or less pronounced bulging interferes with the inspection of the whole membrane so much, that the portion before the handle of the malleus is completely hidden, and sometimes even the handle of the malleus can only partially be seen, the only part of the membrane visible being the posterior superior quadrant.

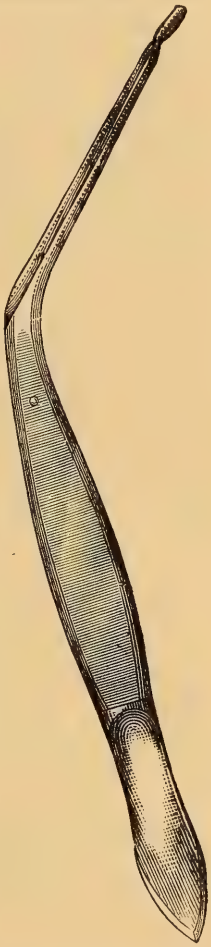

Fig. 68.—Bent Forceps with Cross Blades.

Among the pathological changes which render the membrana tympani temporarily or permanently inaccessible for examination, are specially to be noted: inflammatory affections of the lining membrane of the meatus with stricture, accumulations of pus and mucus, granulations, polypi and exostoses.

Normal State of the Membrana Tympani.—When the membrana tympani is seen perfectly and distinctly with proper illumination, its colour, transparency, lustre, inclination, and curvature, as well as the position of the handle of the malleus and of its short process, have separately to be considered. The relations of these to each other collectively constitute the characteristic appearance of the normal, as well as of the pathologically altered membrane.

Concerning the *colour* of the normal membrana tympani, it must be remembered that this membrane is a more or less transparent medium which reflects a portion of the light thrown upon it, while it permits another portion to pass through it and illumine the tympanic cavity, from the opposite inferior wall of which a portion of this light is reflected back through the membrane, and reaches the observer's eye. The colour of the membrane, as seen, is therefore composite, and depends upon its intrinsic colour, the kind of light employed, and the quantity and colour of the rays reflected

back from the promontory. The nature of the light used has great influence on the colour of the membrane. Thus, light reflected from a blue sky imparts to it a pale blue colour, that from an oil lamp a reddish-yellow tinge. Since the various segments of the membrane are at different distances from the inner wall of the cavum tympani, it follows that they appear to the investigator as being of different colours, although the same kind of light is used throughout.

The normal colour of the membrana tympani is best described as a neutral or pearly gray, with a slight brownish-yellow tinge. The gray is darkest in the anterior portion, at the angle between the handle of the malleus and the cone of light, and lighter in the posterior portion. The colour of the latter part is in many cases modified at the superior boundary by v. Tröltsch's pouch, situated on the inner surface of the membrane. This, with the chorda tympani, shines through the transparent membranes as a whitish-gray opacity, extending from the handle of the malleus backwards. Behind the handle in the posterior superior quadrant, the lower portion of the long crus of the incus (Figs. 69 and 70) is often plainly visible, and the posterior crus of the stapes with the stapedius tendon less frequently so, if the membrane be transparent. The membrane is also slightly yellowish-gray behind and a little above the inferior extremity of the handle of the malleus, which is caused by the bone-yellow rays reflected by the promontory. To this colour is often added a glimmering lustre, due to the light reflected from a moist and smooth spot on the mucous membrane of the promontory. A pronounced dark spot in the posterior inferior quadrant corresponds with the niche of the fenestra rotunda.

In childhood the membrane often appears grayish, opaque, and dim, but not unfrequently transparent and lustrous; however, the gray colour of the membrane is often much darker, and the promontory is much more frequently seen shining through it. There are just as often changes in old age, which are characterized by a uniformly gray and often lustreless appearance of the membrane.

At the inspection of the membrana tympani the short process of the malleus, which is visible at the anterior superior pole as a white, pointed protuberance, catches the eye first (Figs. 69, 70). It is continuous with the handle, which, imbedded in the membrane as a yellowish-white stria, extends backwards and downwards, ending at the umbo in a grayish, spatular expansion.

This 'umbilical opacity' on the membrane, as it is called by Trautmann, is caused partly by the descending and radiating fibres of Prussak at the umbo, and partly, as I have shown, by the deposit of small cartilaginous cells round the lower extremity of the handle of the malleus. Besides that, one finds at the anterior inferior periphery of the membrane a linear gray opacity, corresponding to the annulus tendinosus.

The lustre of the membrana tympani is shown in the sharply defined and usually triangular spot of light in the anterior inferior quadrant of the membrane (Figs. 69 and 70). It commences with its apex in front of the umbo, and extends forwards and downwards, so that it forms an obtuse angle forwards with the direction of the handle of the malleus.

The shape of this light reflex varies greatly, partly on account of differences in the inclination of the membrane, partly on account of variations in its curvature. It is often interrupted in its continuity, so that between its apex and its base there is a portion without reflection; sometimes it seems divided into two parts in its longitudinal direction, or delicately striped. It seldom extends to the periphery of the membrane, and often the anterior portion of the reflection is effaced, only its apex being visible in front of the umbo, as a small, irregular, lustrous spot. According to Bezold, this

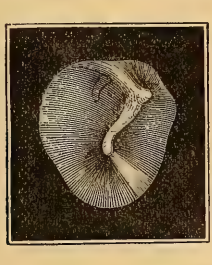

FIG. 69.—NORMAL MEMBRANA TYMPANI OF THE RIGHT EAR.

FIG. 70.—NORMAL MEMBRANA TYMPANI OF THE LEFT EAR.

(Double size.)

spot is blurred in 86 per cent. of cases whose hearing are normal. The knowledge of all these variations in the normal state is of importance, because they might give rise to erroneous interpretations of pathological changes.

As to the origin of the cone of light, the examinations (*A. f. O.*, vol. i.) made by me on artificial membranes and preparations of the normal auditory apparatus have shown that its principal cause is the inclination of the membrane to the axis of the meatus, in connection with the concavity of the membrane produced by the handle of the malleus. In consequence of the curvature of the membrane brought about by the traction of the handle of the malleus, the inclination of the various portions of the membrane is so altered that its anterior portion is placed exactly opposite the eye of the observer, and thus the incident rays are directly reflected to the eye. The triangular shape of the cone of light is caused by the funnel-shaped inward curvature of the membrane (Trautmann).

The form and size of the cone of light undergo many changes in the diseases of the membrana tympani and of the middle ear, which are of special diagnostic value, if we have an opportunity of observing

them during the course of the disease. On the whole, however, these changes of the cone of light only aid the diagnosis in conjunction with other symptoms, as similar alterations are often observed in persons of normal hearing.

Of most importance in diagnosis are those changes in its form which arise by variation of the pressure of air in the tympanic cavity, and which in many cases can be used in determining the permeability of the Eustachian tube. For if air is pressed into the tympanic cavity, or the air in the tympanic cavity is rarefied during an act of swallowing with closed nostrils, a change in the form of the reflection of light will be observed on inspection of the membrana tympani, as necessarily the curvature of the membrane must be altered by these rapid variations in the pressure of air. If we therefore perceive an alteration in the spot of light during the above-named manipulations, we can say with certainty that the tube is permeable. But we can by no means infer the contrary from an absence of change in its form or size, for often not the slightest motion of the membrana tympani, even in the normal state, is visible with very rapid and great changes in the pressure of air, as, for instance, during catheterization, while a manometrical tube, inserted into the meatus, undoubtedly indicates the presence of a change in the curvature.

Besides this cone of light, there are reflections also at other places on the membrana tympani in its normal state, especially a faint lustre on the posterior superior portion, and here and there a small reflection of light from the short process of the hammer and the depression of Shrapnell's membrane, also a small band of light on the antero-inferior periphery of the membrane, which has been called the sulcus reflex by Bezold, because it originates in the groove formed between the membrana tympani and the fold of the sulcus.

The inclination of the membrane in the living subject appears on inspection to be much less than in the anatomical preparations. This fact is of great importance in judging the nature of the changes in the membrane and in operations upon it. Besides, our judgment as to the inclination of the membrane is often influenced by the width of the osseous meatus in such a way, that with a wide meatus the membrane seems to be placed more perpendicularly than with a narrow meatus.

The curvature of the membrane has also an influence upon our ability to judge of its pathological state. It varies in different individuals in the same manner as the inclination, and our judgment of the degree of curvature from inspection in the living is also apt to be faulty, as it appears to us less curved inward than it is in reality.

According to my examinations, the transparency of the membrane exercises an important influence upon the judgment of its curvature.

The more transparent the membrane, the less it seems curved; the more opaque the membrane, the more the funnel-shaped concavity of the external surface seems to project.

If we take a general survey of the foregoing, the following normal appearance of the membrane tympani may be seen. At the anterior superior pole of the membrane (Figs. 69 and 70) there is seen a whitish projecting spot, *the short process of the malleus*, from which there extends backwards, downwards, and towards the centre of the membrane a whitish or yellowish process, expanding like a spatula at its inferior extremity, *the handle of the malleus*. In front of and below the extremity of the handle there is a triangular spot of light, *the cone of light*, with its apex at the umbo and its base directed forwards and downwards towards the periphery. The portion of the membrana tympani between the handle of the malleus, the cone of light, and the anterior wall of the meatus, generally of a darker gray

FIG. 71.—SIEGLE'S PNEUMATIC EAR-SPECULUM.
(Speculum ½ size, balloon ¼ size.)

than the rest of the membrane, is seldom seen in adults, but is visible in children in two-thirds of the cases (Bezold) as far as the periphery; the portion behind the handle, which is separated from the posterior superior wall of the meatus by a lightish-coloured line, more or less pronounced, appears much larger and lighter in its colour, the latter being modified as above described (*v.* p. 76).

Pneumatic Speculum. — To the above-mentioned methods of examining the membrana tympani must be added that with the pneumatic speculum, a method most important for the diagnosis of affections of the middle ear, and by the invention of which Siegle (*Deutsche Klinik*, 1864) has won everlasting fame. This instrument (Fig. 71) differs from the ordinary speculum in having its outer end closed by an obliquely-inserted plate of glass—which must be inserted as far as possible into the speculum so as to avoid the disturbing effect of reflected rays of light—and a small nipple projecting from its side, to which is fastened an india-rubber tube furnished with a small balloon. By means of an olive-shaped nozzle

(Delstanche, Fig. 72), or by putting a small piece of india-rubber tubing on the nozzle (of which it has three sizes), the instrument can be hermetically fixed in the external meatus.

To examine the membrane, the speculum, inserted into the meatus, is fixed with the left hand, so that reflection from the glass plate does not interfere with the examination. Then the membrana tympani is illuminated by means of the concave mirror, and the air in the external meatus is alternately condensed and rarefied by the balloon, by compressing it slightly with two fingers of the right hand, quickly releasing it after each pressure. Condensation of air by blowing into the speculum with the mouth is unsuitable, as the inner surface of the glass is dimmed by the condensed breath.

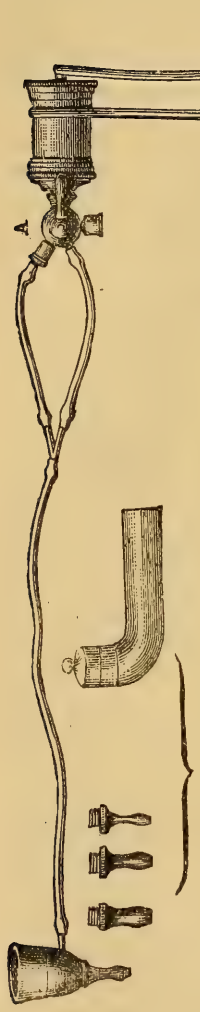

Fig. 72.

In place of the small balloon one can use the 'rarefacteur' invented by Charles Delstanche (Fig. 72), which is provided with a double valve. It is used with the Siegle speculum as well for diagnostic as therapeutical purposes, and has the advantage, according to the direction of the stopcock A, of either alternately condensing and rarefying the air in the external meatus or of rarefying it only. Its action is more energetic than the ordinary Siegle speculum, and is able by aspiration to replace an abnormally depressed membrane nearer to its proper position.

In the normal state, during this method of examination, considerable movement of the membrana tympani is observed, greatest midway between the malleus and the periphery. The most striking sign of movement is the change in the form of the cone of light, which becomes considerably smaller during condensation. But on close inspection of the handle of the malleus a very distinct movement of it is also visible, for during condensation either its inferior extremity moves downwards and inwards, or the whole handle moves in this direction. This mobility of the handle of the malleus undergoes many changes in disease of the middle ear, being lost either partially or completely by thickening and inflexibility of the membrana tympani, or by rigidity and anchylosis of the articulation of the

malleus and incus, or lastly, by abnormal adhesion of the head of the malleus to the adjacent walls of the tympanic cavity.

As Siegle has mentioned, the pneumatic speculum is used with most success in cases where it is required to ascertain whether the membrana tympani, through thickening of its layers, has decreased mobility, or through atrophy and formation of cicatrices the mobility is increased; and farther, if some of its parts be adherent to the inner wall of the tympanic cavity. The examination shows that those portions of the membrane which are united with the opposite wall of the tympanic cavity remain unmoved during condensation and rarefaction of air with this instrument, or make only slight excursions, while the portions which are not adherent exhibit a distinct movement.

The changes in the bloodvessels of the membrana tympani and in the external meatus during this mode of examination is, according to my observations, of special interest. For if these vessels are strongly injected, that injection will partly or altogether disappear during the condensation of air with the pneumatic speculum; as soon, however, as the condensation of air ceases, the bloodvessels quickly fill again.

B. Methods of Examination of the Middle Ear.

Among the methods of examination of the organ of hearing, the various means for examining the state of the Eustachian tube and of the tympanic cavity hold a prominent place. By their aid we are often able to obtain information with regard not only to the permeability of the Eustachian tube, but also to the presence of diseased products in the middle ear, and to the state of the membrana tympani. But these methods are of still greater importance in the treatment of the affections of the middle ear, as they supply us with the means of conducting therapeutic agents in the form of compressed air, gases, vapours, or fluids into the tympanic cavity.

These methods are:

a. The Valsalvan Method.
b. Catheterization of the Eustachian Tube.
c. The Method of the Author, so called Politzer's Method, for effecting the Permeability of the Eustachian Tube.

Before commencing the description of these methods, it is advisable, with regard to the estimation of their therapeutic value, to make a few remarks about the mechanical action of compressed air in diseases of the middle ear.

On the Mechanical Action of Currents of Air introduced into the Tympanum in the Diseases of the Middle Ear.

The main purpose of the methods now about to be described is to effect the permeability of the Eustachian tube for diagnostic purposes, and to conduct compressed air into the middle ear to remove or lessen the anomalies of tension and the obstacles to the conduction of sound, which disturb the function of hearing.

The first effect of a current of air conducted from the pharynx to the middle ear is produced in the Eustachian tube, the walls of which, lying against each other in the normal state, are forced asunder, and its lumen widened. If the tube is obstructed by swelling and œdema of its membrane, or by accumulation of secretion, so that the entrance of the tube cannot be made to gape by an act of swallowing, the permeability of the canal and the communication between the air in the tympanic cavity and that in the pharynx are re-established by the introduction of a current of air. By the action of the current of air that part of the secretion which is deposited near the pharyngeal orifice is forced into the pharynx, while that in the superior portion of the tube is forced towards the tympanic cavity.

The effect of such a current of air upon the Eustachian tube is by no means momentary or temporary, as many assert, for experience shows that the constricted tube is often mechanically dilated by the pressure of the air on its walls, and the tumefaction of the hyperæmic and swollen mucous membrane is lessened or quite removed by the action of the air-current, because the blood is gradually displaced from the dilated vessels.

The current of air which penetrates into the tympanic cavity through the tube will in the first instance act upon the inner surface of the flexible membrana tympani, bulging it out towards the lumen of the external meatus. As we have already seen, the malleus, connected with the membrane, and to a less degree also the incus and the stapes, will follow this outward movement. Therefore, as in diseases of the middle ear, the membrana tympani with the ossicular chain is very often abnormally tightly stretched inwards, and the propagation of sound thereby much hindered, the membrana tympani and the ossicula are forced back into their normal position by the introduction of a current of air, if applied with sufficient force, and by thus removing the abnormal tension of the sound-conducting apparatus, its power of vibration is partially or totally re-established.

Indeed, experience shows where hardness of hearing exists in consequence of the closure of the Eustachian tube and the rare-

faction of air in the middle ear caused thereby, a striking improvement in the hearing will take place immediately after the propulsion of air into the middle ear. The abnormal tension of the hearing-apparatus, which is caused by tightness of the ligaments of the ossicula, by retraction of the tendon of the tensor tympani and by newly formed bands of connective tissue, stretched out between the membrana tympani, the ossicula, and the walls of the tympanic cavity, is often decreased by the pressure of a strong current of air in the middle ear, the membrana tympani and the ossicula moving outwards, and the tight ligaments and bands being stretched.

The current of air entering into the tympanic cavity exercises pressure not only upon the inner surface of the membrana tympani, but at the same time upon the fenestræ rotunda and ovalis. If, therefore, the tissues closing these fenestræ have become inflexible through inflammatory thickening, they will become relaxed and more mobile by the repeated action of the compressed air, and consequently the waves of sound will be more readily propagated.

Of course the variations in pressure of air in the tympanic cavity will also have an important influence upon the relative pressure in the labyrinth (*vide* p. 66), for the inflammatory affections of the middle ear are very frequently associated with increased pressure in the labyrinth, partly in consequence of its two fenestræ being clogged with exudation, partly in consequence of the abnormally increased tension of the sound-conducting apparatus, by which the stapes is pushed in too strongly towards the vestibule. If this abnormal tension is removed by a current of air, and the foot-plate of the stapes is moved outwards, the abnormally increased pressure in the labyrinth, and the subjective noises and disturbances of hearing which often accompany it, will be lessened or totally removed.

The air-douche is also of considerable importance in the removal of exudation from the middle ear, but the mechanical action of the compressed air in this instance must be closely examined in regard to its effects upon exudative accumulations both with and without perforation of the membrana tympani. The view which was formerly current, viz., that in cases of catarrh of the middle ear unaccompanied by perforation of the membrane, the improvement in hearing following the use of the pneumatic douche was brought about by the expulsion of the exudation from the tympanic cavity, has been considerably modified by experiments made by me on human ears. These experiments showed that the larger portion of the secretion, especially if of a tenacious character, remains in the cavum tympani, even when a strong current of air is used; and that the improve-

ment in hearing which immediately follows the action of the douche is brought about chiefly by the removal of the abnormal tension in the tympanic cavity. Fluid exudation in the middle ear is, however, often partially or completely removed by an inflation of air, if the head is much inclined forwards and sideways during the operation. The position of the tube is thus changed, so that the ostium tymp. tubæ is directed exactly upwards, and the ostium pharyngeum exactly downwards, and thus, when the tube is opened, fluid can gravitate from the tympanic cavity into the naso-pharynx.

If, then, a cure is effected by the frequent propulsion of air in a number of cases where the exudation cannot be mechanically removed by the current, it is simply due to the absorption of the secretion in consequence of the re-establishment of the normal pressure of air in the tympanic cavity. For, as already mentioned, the air is rarefied in the tympanic cavity by the closure of the Eustachian tube in affections of the middle ear, combined with swelling and hyper-secretion. Hence the blood and lymphatic vessels of the mucous membrane of the cavity will be under a subnormal pressure of air, a condition which is favourable to the exudation of fluid from the vessels into the tympanic cavity.

I am of the opinion that by propelling air into the tympanic cavity in these cases, the circulation in the blood and lymphatic vessels again becomes normal on the re-establishment of the normal air-pressure, and thus the absorption of the secretion is effected. I formed this opinion from the observation of cases where an acute inflammation of the middle ear, accompanied by marked injection and opacity of the membrana tympani, had already lasted for several weeks or months, and where no increase in the hearing-distance was observed previous to the treatment. If in such cases a current of air is conducted into the middle ear, not only will a considerable improvement in the hearing immediately take place, but also a noticeable change in the membrana tympani will be observed during the following days, while the improvement in the hearing makes still further progress after the repeated introduction of air. First the injected radiating vessels disappear, and then the peripheral vascular wreath, the membrane becomes more transparent, its lustre returns, and with the removal of the hardness of hearing, the membrana tympani has, as a rule, regained its normal appearance.

It is sufficiently clear from these observations that the exudations lying in the tympanic cavity in cases of closure of the tube, together with the abnormally decreased air-pressure, keep up the hyperæmia in the middle ear, as the dilated vessels on the external surface of

the membrana tympani prove. The speedy disappearance of a hyperæmia which has existed for some time, and of hardness of hearing after air has been injected several times into the tympanic cavity, demonstrate the favourable effect of the air-douche in bringing about a re-establishment of the circulation in the middle ear and the absorption of the exudation.

The effect of the propulsion of air into the middle ear with a perforated membrana tympani is essentially different from the results hitherto described. For, as the current of air, entering through the Eustachian tube, escapes through the perforation, the secretion deposited in the tube and in the tympanic cavity will be forced immediately through the aperture in the membrane into the external meatus, and pus and mucus are in this manner removed from the middle ear. The current of air has the same effect in cases of exudation in the middle ear, where the membrana tympani has been artificially perforated. In these cases serum, mucus, or pus will be forced out of the cavum tympani through the artificial opening into the external meatus, and the cavum tympani emptied, as is not possible with an intact membrana tympani.

In cases of perforation of the membrane, the current of air which is caused to rush through the middle ear and the external meatus is not without influence on the position of the ossicula, in spite of its escape through the aperture. Even if the air which rushes through the Eustachian tube escapes into the external meatus, the current acts also at the same time upon the internal surface of the remnant of the membrane, and forces it and the ossicula outward into an approximately normal position.

The view that, in perforative inflammation of the middle ear, pustular secretion in the middle ear is forced into the mastoid cells by the air-douche, has been disproved by Michel (*A. f. O.*, vol. xi.), who proved that the secretion is always forced into the external meatus.

a. The Valsalvan Method.

The Valsalvan method consists in condensing the air in the naso-pharynx by a strong act of expiration, performed with closed mouth and nostrils. By this means the walls of the Eustachian tube are forced asunder, and the condensed air is propelled into the tympanic cavity.

In the first place, it is important to mention that the manometrical pressure effected by the Valsalvan method varies according to the age of the individual, and according to the individual power of the expiratory muscles. Hence the pressure will be far

less in children than in adults, and also considerably less in weakly than in robust individuals. Waldenburg's experiments prove also that there is considerable difference in the amount of the expiratory pressure in the two sexes, as in males it amounts on an average to 100-130 mm., in females to 70-110 mm., as indicated by the quicksilver column.

During the execution of the Valsalvan method the obstructions opposed to the entrance of air into the tympanum of a normal ear are situated partly in the Eustachian tube, partly in the membrana tympani. Since the walls of the Eustachian tube are closely approximated to each other, but to a different degree in different individuals, the expiratory pressure necessary to force the air into the tympanic cavity must consequently be greater the closer the walls of the tube are in contact, whilst the muscles of the tube are at rest. The membrana tympani itself forms no small hindrance to the current of air, and the pressure which is required to overcome its tension and to bulge it outwards towards the meatus, is not inconsiderable. According to Hartmann, a pressure of, on an average, 20-40 mm. Hg. suffices to force the air into the tympanic cavity under normal conditions.

The entrance of air into the tympanic cavity during the Valsalvan method can be proved by inspection of the membrana tympani as well as by auscultation. If the membrane of a normal ear be inspected during the Valsalvan method, an outward curvature of the portions situated between the handle of the malleus and the periphery will be seen. The change in the form of the cone of light will specially attract attention, as a rule it is shortened and narrowed, and in some rare cases even disappears (Moos). A slight excursion of the lower end of the handle of the malleus forward and outward occasionally occurs. Often no movement of the membrana tympani occurs during the use of Valsalva's method.

The air which penetrates into the tympanic cavity produces a noise in the middle ear, which can be perceived either by placing the auricle immediately to the concha of the person being examined, or in a more practical manner by the auscultation tube (Otoscope; *v.* Catheterization of the Eustachian Tube) designed by Toynbee.

This short, puffing sound, which is often preceded by a slight murmur caused by the friction of the air in the Eustachian tube, is generally called the sound of the concussion of the air on the membrana tympani, and is produced by the rapid outward movement of the portions of the membrane situated between the handle of the malleus and the periphery, as I have ascertained by numerous experiments made on fresh ear specimens. The sound is therefore

caused by the movement of the membrane itself, and not by the concussion of the air, and it should for this reason be more correctly described as the sound caused by the bulging out of the membrane.

While the Valsalvan method often fails to effect the entrance of air into the middle ear in normal ears, it does so still more frequently in abnormal ones. Hartmann found that with a slight swelling of the mucous membrane of the Eustachian tube, with no disturbance of hearing, as often occurs with naso-pharyngeal catarrhs, the manometrical pressure was increased to 100-120 before the Valsalvan method was successful. A still more considerable increase in the pressure is required in cases of disease, especially in the affections of the middle ear accompanied by swelling and secretion. As they are generally combined with a tumid state of the mucous membrane of the tube, and therefore with stricture of the isthmus tubæ, such an obstruction to the entering current of air is offered that it is often impossible to overcome it by the greatest expiratory pressure.

This is especially the case in that group of affections of the middle ear which run their course without perforation of the membrana tympani. In this group obstructions besides those in the Eustachian tube, as swelling, plugging with mucus and crusts, and connective-tissue strictures, such other obstructions as accumulated secretion in the middle ear, great tension of the membrana tympani, and a greater adhesion of the walls of the Eustachian tube, caused by the rarefaction of air in the cavum tympani, increase the difficulty of forcing air into the middle ear. It must be mentioned, however, that in certain rare cases in which a notably greater pressure is brought to bear, *e.g.*, as in catheterization, or in my method, air cannot be forced into the middle ear, or only with great difficulty, the Valsalvan method is nevertheless successful.

However, in that group of the affections of the middle ear where the membrana tympani is perforated, the Valsalvan method may be much more frequently used as a means of diagnosis. For here the resistance of the membrane has ceased; a counter-opening has been made into the tympanic cavity, which considerably facilitates the entrance of a current of air through the tube into the tympanum. Although in many cases of perforation of the membrana tympani the exit of the air through the meatus, during the Valsalvan method, is accompanied by a perceptible sound, it must not be inferred from the absence of the hissing noise that the membrana tympani is not perforated, because extensive swelling of the mucous membrane of the tube, granulations and inspissated

secretion in the cavum tympani and external meatus, may hinder the entrance of the air into the middle ear.

To sum up, it will be found that the Valsalvan method as a means of diagnosis is certainly of limited value, but, nevertheless, it can be used in a great number of cases. If it gives a positive result, we may, generally speaking, infer that the mechanical obstruction in the Eustachian tube is slight; if, however, it give a negative result, we may assume that, the membrana tympani being intact, or even perforated, a greater obstacle exists in the Eustachian tube or elsewhere in the middle ear. From my experience, these results are of no slight importance in prognosis, for in inflammations of the middle ear, accompanied by swelling and secretion, the prognosis in regard to speedy removal of the pathological changes will, on the whole, be more favourable in those cases where the permeability of the tube can be effected by the Valsalvan method, than in those in which the application of the catheter or of my method is necessary. The examination of the middle ear should therefore always be commenced with the Valsalvan method, to be followed by my method and by catheterization.

The therapeutic value of the Valsalvan method will be discussed in the division in which the effects of the methods enumerated at the commencement of this division are compared.

A method called Toynbee's experiment remains to be mentioned. It consists in performing the act of swallowing with closed nostrils, whereby a feeling of fulness in the ears arises, which was erroneously attributed by Toynbee to condensation of the air in the middle ear (compare p. 63). This experiment is, however, of but small value, because the cracking sound which should thereby be heard in the normal ear, is often imperceptible, but is perfectly audible in pathological cases in which the tube is impermeable. Equally unreliable is the experiment for purposes of inspection, because where the ear is healthy every evidence of the movement of the membrane may be wanting, whereas in cases in which the Eustachian tube is impermeable, movements of the membrane may be perceived.

b. Catheterization of the Eustachian Tube.

Catheterization of the Eustachian tube consists in the introduction of a Eustachian catheter through the nose, or more rarely through the mouth, into the tube. This is one of the most important operations performed in the diseases of the ear. For not only does the catheter give more reliable information as to the state of the middle ear than the other methods of examination, but it is also quite indispensable as a means of conducting gaseous or fluid agents into the middle ear for remedial purposes.

In consideration of the importance of this subject we will describe the anatomical relations of the naso-pharynx, which have to be considered during catheterism, before entering on the details of the method.*

1. *Topographical Relations of the Pharyngeal Orifice of the Eustachian Tube.*

The pharyngeal orifice of the Eustachian tube (Fig. 73, *h*) is situated on the lateral wall of the pharynx, at a level with the horizontal prolongation of the inferior turbinated bone. It presents an oval depression, pointing obliquely downwards, which is bordered in front by an ill-defined swelling, above and behind, however, by a strong, firm lip, projecting towards the pharynx.

The anterior lip is separated from the lateral wall of the nose by the sulcus nasalis posterior. An extensive fold, the plica salpingo-pharyngea, extends from the posterior lip of the tube to the superior portion of the arcus palato-pharyngeus.

Between the posterior lip and the posterior wall of the pharynx there is a depression, Rosenmüller's fossa (*g*), which is rich in glandular tissue, and subject to great individual variations in size. In consequence of chronic pharyngeal catarrh, a cystic hypertrophy of the closed mucous glands, their amalgamation with the originally existing depressions of the mucous membrane in this place, and formation of extensive gaps and bridge-like bands often occur, by which the operation of catheterization is sometimes rendered difficult, especially when the operator allows the beak of the catheter to become entangled in these bands.

The distance of the orifice of the tube from the posterior pharyngeal wall will, therefore, not only vary in different individuals (according to L. Mayer it amounts on an average to 1·8 cm.), but it will also depend on the degree of swelling of the mucous membrane of the pharynx. For this reason it is impossible to employ the distance between the orifice of the tube and the posterior wall of the pharynx as a safe guide in the introduction of the catheter.

Below the orifice of the tube is the velum palati (*e*), which in the living arches upwards above the level of the hard palate. The muscles which enter it from the tube and from the palatine arches give to it a considerable degree of mobility, tension, and power of resistance. Every movement of the velum palati has associated with it a movement in the Eustachian tube, and the posterior extremity of a catheter undergoes a perceptible change of position at every motion of the soft palate, if the catheter either comes into contact with the velum or be introduced into the tube.

* The invention of catheterizing the tubæ Eustachia was first described by a postmaster named Guyot in a report sent to the Paris Academy in 1724, in which he gave an account of his own cure by the means of a tube introduced into the Eustachian tube through the mouth. The catheterization through the nose was first done by Archibald Cleland, but according to the French by Petit. The diagnostic and therapeutic worth was first proved by Saissy, Itard, and Deleau, later by Kuh, Kramer, Cerutti, and v. Tröltsch, who first gave the positive indications for its use.

In the nasal cavity, lying in front of the Eustachian tube, the three turbinated bones on the outer wall and the nasal septum merit description. The superior turbinated bone (*c*) is short and narrow, while the middle (*b*), and especially the inferior (*a*) turbinated bones, project more into the nasal cavity. Hence there arise below these curved bones the three nasal meatuses, of which the lower, according to Woakes a prolongation of the Eustachian tube to the nasal orifice, is of special importance in catheterization.

In the performance of catheterization of the Eustachian tube, besides the obstacles produced by pathological processes which will

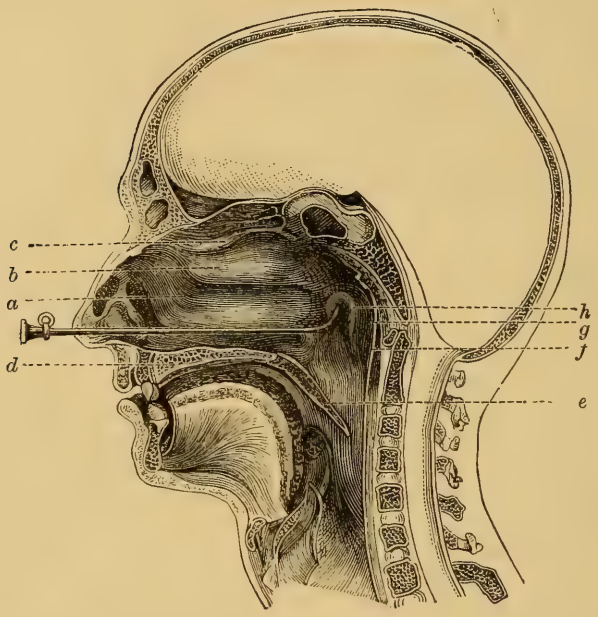

FIG. 73.—VERTICAL SECTION OF THE NASO-PHARYNX WITH THE CATHETER INTRODUCED INTO THE EUSTACHIAN TUBE.

a, Inferior turbinated bone; *b*, Middle turbinated bone; *c*, Superior turbinated bone; *d*, Hard palate; *e*, Velum palati; *f*, Posterior pharyngeal wall; *g*, Rosenmüller's cavity; *h*, Posterior lip of the orifice of the Eustachian tube.

be described later on, there have to be considered the frequent congenital deformities of the nasal septum and of the turbinated bones. For if a considerable collection of crania be examined, it will be found that the septum of the nose seldom represents a perpendicular plane, but that it is more or less bulged out, sometimes to one side and sometimes to the other (more frequently towards the left side), by which one half of the nose is greatly narrowed, while the other

is proportionately more spacious.* By excessive development of the middle, but more often of the inferior, turbinated bone, the permeability of the nose is often impaired, and the contraction will reach a higher degree if an enlargement of the turbinated bones is combined with a bulging out of the nasal septum towards the same side.

The distance of the orifice of the Eustachian tube from the posterior nares is as variable as from the posterior pharyngeal wall. Not only is it generally less in the female than in the male, but great fluctuations occur with variations in the cranial formation—*e.g.*, in prognathous people it is mostly greater than in orthognathous; therefore the distance from the entrance of the nose to the orifice of the tube cannot be used as a guide in catheterization.

2. *Choice of Catheter.*

For catheterization I almost invariably use instruments made of vulcanite, as first proposed by me (Fig. 74). Their length is 13-16 cm.,† the length of the beak being 2-2½ cm., with a curvature of 145°. A metal ring fixed to the posterior widened extremity corresponds with the concavity of the curvature of the beak, and serves to indicate the direction of the point of the catheter when the instrument is in the naso-pharynx. The unpleasant sensation caused by the contact of the metal instrument with the mucous membrane is not felt when these catheters are used; and, indeed, experience shows that patients almost without exception prefer the treatment with the vulcanite catheter to that with the metal instrument, a fact which is not to be undervalued in practice. The metal catheters also cause pain by pressure upon the inflexible walls of the nasal passages, while the vulcanite ones more easily follow the curvatures of the nasal cavity on account of their elasticity. This moderate degree of elasticity, however, by no means impairs the firmness of the instrument, which is required in order to feel the sliding of its beak over the posterior lip of the tube, or the resistance at the posterior margin of the nasal septum.

The objection that vulcanite catheters might easily be broken in meeting obstacles in the nose, is met by the fact that forced catheterism is inadmissible in cases of stricture in the nasal cavity.

The selection of the proper sized catheter is of great importance in practice. I use catheters of four sizes, of which the diameter of the thickest (No. 4) is 3½ mm., the next (No. 3) 3 mm., the medium size, which is the most used (No. 2), 2½ mm., and the thinnest (No. 1) 1½ mm.; the thickness of the catheter wall measures ½ mm. The catheters which I have lately brought into practice, with an oval opening at the smaller end, have the advantage that the oval point of the catheter fits more closely into the slit-like

* Thiele (*Zeitschrift f. rat. Med.*, vol. vi.) found that in 88 out of 117 skulls the septum was bent.

† The shorter catheters proposed by Lucæ have certainly the advantage that they offer less resistance to the air passing through them, but those made of vulcanite do not possess the same amount of flexibility as the longer ones.

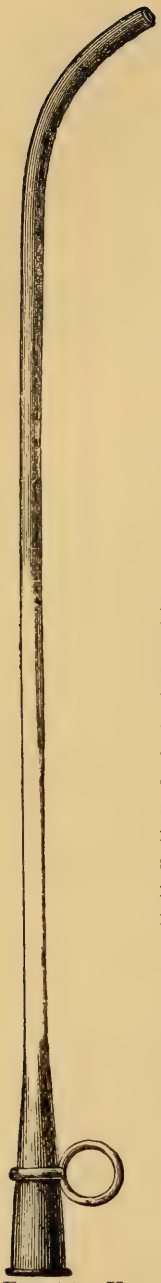

Fig. 74.—Vulcanite Catheter of Medium Thickness.

aperture of the tube, so that air and fluids can be injected into the middle ear with more force than with the round pointed ones. The long direction of the oval opening is on an axis with the curvature of the catheter.

The average curvature of the catheter, as given above, of 145°, is not proper for all cases. Where there are larger obstructions in the nasal and post-nasal cavities, which increase the difficulty of introducing and turning a normally curved catheter, it is necessary to change the angle of curvature, either by warming over an alcohol flame or dipping in warm water. The therapeutic action of such flat curved catheters is much less, as the point cannot be introduced far enough into the Eustachian tube.

On the other hand, it is necessary occasionally to use catheters with a long and strongly-curved beak. These catheters are used only in such cases where by the use of normally-curved catheters, the Eustachian tube cannot be made pervious, or where one wishes to inject a large quantity of fluid into the middle ear. Air and fluid can be injected so much more surely through the narrowest part of the tube into the cavum tympani, the deeper the point of the catheter penetrates the tube.

The possibility of inoculation with syphilis by means of the catheter, a fact which was first established in Paris, necessitates the greatest care in using these instruments. In my own practice a special instrument is reserved for each patient during the whole course of treatment, a precaution which every practitioner is bound to observe, not only for the absolute safety of the patient, but also to abolish any possible fear of infection on the part of the patient. Doctors with a small practice, who only have a limited number of instruments at their disposal, should invariably cleanse the instruments themselves. Directly after the use of the catheter, it should be placed in a solution of corrosive sublimate (1 : 1000), from which it should not be removed until the following day, when, in addition to being washed in warm water and thoroughly syringed out, the beak should be carefully wiped out with a piece of fine linen. Instruments which have been used on persons well known to be infected must on no account be used again.

3. *Method of Catheterizing the Eustachian Tube.*

Of the numerous methods which have been recommended for the performance of catheterization, two specially deserve a detailed description because in carrying them out fixed anatomical relations serve as

guides for the introduction of the catheter into the tube, and because they have proved, from experience gained in practical classes, not only to be safest, but also to supplement one another. The anatomical guides in question are the posterior lip of the tube together with the rigidly extended plica-salpingo-pharyngea and the posterior margin of the septum of the nose.

Catheterization of the Eustachian tube, in order to avoid painful sensation to the patient, must be performed with the greatest care. It is my opinion that the operation should be carried out in the sitting position. Patient and surgeon should be so placed that the table, on which the necessary instruments are placed, is to the right of the surgeon. It will be found as well to use a high-backed chair so that the patient's head may not slip too far backwards during the operation. To introduce the catheter with as little unpleasantness as possible to the patient, the point of the nose is first tilted up with the thumb of the left hand, and the head is steadied by placing the other four fingers against the forehead. Then the posterior extremity of the catheter is taken between the thumb, forefinger, and middle finger of the right hand like a pen, and is slightly depressed while the beak is introduced into the nasal cavity.

The point of the beak is now lowered to the floor of the nasal cavity, the posterior extremity of the catheter being lifted up until the instrument is in a horizontal position; it is then moved backwards, the beak being constantly in contact with the nasal floor. In a normal nasal cavity the catheter passes between the turbinated bones and the nasal septum (more rarely in the space formed by the inferior turbinated bone) backwards along the osseous floor, without noticeable change in the direction of its beak, and then glides across the superior surface of the soft palate to the posterior wall of the pharynx. During all these manipulations the catheter must be held as loosely as possible in the fingers, so that its beak may easily glide over any obstruction and the patient be spared unnecessary pain.

By that method in which the posterior lip of the tube serves as an anatomical guide, as soon as the catheter has reached the posterior wall of the pharynx its beak is turned outwards and slightly forced into Rosenmüller's fossa. While its posterior extremity is somewhat raised, the catheter is retracted with moderate rapidity, during which movement the beak of the catheter will be felt to slip over the bulging lip of the tube, projecting from the lateral wall of the pharynx.

After the point of the catheter has thus passed the posterior lip, it has arrived at the pharyngeal orifice of the Eustachian tube. To insert the beak into the tube it is now sufficient to turn the instru-

ment so far outwards, that the metal ring fastened to its posterior extremity is pointed towards the outer canthus of the eye of the same side. This direction of the beak corresponds as a rule with the axis of the Eustachian tube. This method which, according to Ph. H. Wolf (Lincke, vol. iii., p. 360) was first proposed by Kuh, is described as Bonnafont's or Kramer's method, and I consider it, in spite of the opposite view held by Schwartze (*l. c.*, p. 25) together with Löwenberg's method, to be the safest for the general practitioner.

By the second method, given by Löwenberg, the posterior edge of the septum is used as the anatomical guide.

After the catheter has been introduced, exactly as in the previ-

FIG. 75.—FIXING OF THE CATHETER INTRODUCED INTO THE EUSTACHIAN TUBE WITH THE LEFT HAND.

ously described method, as far as the posterior wall of the pharynx, its point is not turned outwards, as in the former method, but inwards, towards the orifice of the other Eustachian tube, and is brought into a horizontal position, as ascertained by the position of the metal ring on its end. The outer end of the catheter is then moved slightly outwards, and gradually drawn back until the beak has reached the posterior margin of the nasal septum. During moderate traction a noticeable resistance will be felt at this place, which prevents the catheter from being drawn further back, because its hoop-shaped, curved beak grasps the posterior margin of the nasal septum. Drawing the catheter too strongly against this moderate resistance is apt to interfere with the success of this method. The catheter is now moved towards the septum of the nose, taken hold of with the left forefinger and thumb close to the point of the nose, and its beak rotated downwards, and the instrument turned on its long axis more than 180°. The point of the

beak is inserted in this manner into the pharyngeal orifice of the Eustachian tube, provided that the catheter during the last rotation was not displaced either forwards or backwards, and that no deformities exist in the posterior portion of the naso-pharynx or near the orifice of the tube. Sometimes the tightly stretched velum palati offers great resistance to the rotation of the catheter downwards, whereby the point of the instrument is forced backwards, and its introduction into the orifice of the tube is prevented. If the point of the catheter has entered the orifice, the instrument is brought into the proper position and fixed exactly as in the previous method. After the catheter has been introduced into the tube, a fact which can be demonstrated either by auscultation while air is

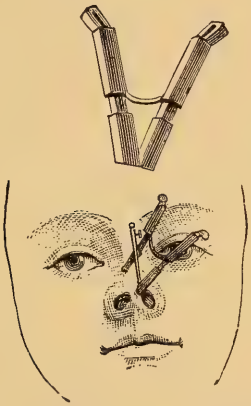

Fig. 76.—Delstanche's Nose Clamp.

being forced through it, or by pharyngoscopy, the instrument is seized close in front of the nose with the left thumb and forefinger, and to fix it firmly in this position the other three fingers of the left hand are laid upon the bridge of the nose (Fig. 75).

Only when the catheter has to remain for a considerable time in the Eustachian tube for the introduction of vapours into the middle ear, do I make use of Dr. Ch. Delstanche's simple and effective nose-clamp (Fig. 76) to hold the instrument in position. This nose-clamp consists of a whalebone rod which, after being dipped in hot water, is bent into an M shape so that the large cruræ squeeze the alæ of the nose together and fix the catheter. This instrument renders the complicated and unpleasant instruments of Kramer, Rau, and Bonnafont useless.

In drawing a comparison as to the value of the respective methods, it must be borne in mind that Bonnafont's method is specially

unsuited for such cases as have the posterior lip of the tube flattened or levelled either by ulceration, by cicatricial formation on the lateral pharyngeal wall, by the atrophy of old age, or by shrivelling in consequence of chronic catarrh, or where through abnormality of the turbinateds and septum the point of the catheter cannot be brought close enough to the side of the pharynx. The application of this method is just as difficult if great œdema of the posterior pharynx or the existence of granulations and adenoid growths in that cavity offer obstacles to the finding of the posterior lip of the tube.

In such cases our object will be effected more quickly and safely by the Löwenberg method. This procedure, which has been made use of by Frank and Löwenberg, except in some rare cases,* I have found to be an excellent and generally applicable method, and the necessary skill for its execution is much more readily acquired than for other methods. But, on the other hand, it must not be forgotten that it is impossible in many cases, with a normal state of the naso-pharynx as well as with obstructions in its posterior portion, to introduce the catheter into the Eustachian tube by this method, while it is effected without the least difficulty by the first-described procedure. The value of these two methods lies principally in the fact that in many cases one supplements the other.

In the largely used method of Kramer, according to the description of v. Tröltsch (*l. c.*, p. 202†), the catheter, pushed forward to the posterior pharyngeal wall, is drawn back 2-3½ cm. (¾-1 inch), and its beak, directed downwards, is then rotated outwards and upwards through an angle of 135°, whereby it is supposed to enter the orifice of the tube. But here all anatomical guidance for the finding of the orifice is wanting, and the inefficiency of this method is best characterized by the assertion of v. Tröltsch, that the instrument is often drawn back either too far or too little, in which latter case Rosenmüller's cavity instead of the Eustachian tube will be reached.

In case of great irritability of the soft palate and of the mucous membrane of the pharynx, catheterization after the above methods often produces spasmodic coughing and vomiting, which impede the execution of the operation. The following method can here be recommended as the most useful. The catheter, introduced into the nasal cavity, and sliding with its point over the base, is gradually turned outwards, before it leaves the hard palate, in such a manner that the metal ring at the posterior extremity is placed in an oblique position, directed outwards and downwards. If in this position the instrument is pushed backwards, its point, without touching the soft palate, will enter the orifice of the tube, while the posterior lip of the tube prevents the instrument from reaching Rosenmüller's cavity (Triquet). I apply this

* *Zur Technik des Catheterismus der Ohrtrompete, Wiener Med. Presse*, 1872.

† This differs from the description in Kramer's *Die Erkenntniss und Heilung der Ohrenkrankheiten*, 1849, p. 484, in so far as in it mention is also made of the sliding over the lip of the tube.

modification very often in a quite normal state of the naso-pharynx. The method of Boyer and Gairal, by which the catheter after passing through the nose is turned 90° outwards and then pushed backward on a line outwards and upwards until its point reaches the ostium tubæ, can only be recommended for experts.

Lastly, we will mention another modification of catheterization, which some years ago was asserted to be a new one, but which had already been described in old works (Lincke, vol. iii., p. 359, and Rau, p. 117). It consists of drawing back the catheter with its point directed downwards, after the instrument has been pushed forward to the posterior pharyngeal wall, until it meets with resistance at the palate, when by a quarter turn the catheter is supposed to enter the orifice of the tube. With this modification, just as with any other method, it will be often possible to perform catheterization after long practice, but it does not afford the same certainty to the less experienced surgeon as the first-described methods, because the position of the soft palate varies very much, and because it often yields more or less to the pressure of the beak of the catheter.

4. *Mistakes in Catheterization.*

Of the mistakes which may happen even under normal conditions, and which prevent the success of the operation may be mentioned:

1. The point of the catheter is not laid upon the floor of the nasal cavity during its introduction, but pushed towards the upper portion of the nose; the instrument will then, as a rule, enter the middle nasal meatus, and be detained there, so that the beak cannot be turned towards the pharyngeal orifice.

2. The catheter is correctly pushed forward to the posterior wall of the pharynx, but the outer extremity of the instrument is not tilted up sufficiently; in this way the point of the catheter, instead of slipping over the lip of the tube, passes above its pharyngeal orifice.

3. The point of the catheter is in Rosenmüller's cavity, but while drawing it back, the posterior lip of the tube offers such a great resistance, that it may lead to the belief that the instrument is detained in the tube.

4. The beak of the catheter is drawn over the posterior lip of the tube, but instead of performing the rotation of the instrument, which is necessary for its entrance into the tube, immediately after the point has slid over the lip, it is drawn still farther outwards. In this case the point of the catheter is often detained by the protuberance at the posterior extremity of the inferior turbinated bone, which may also give rise to the erroneous assumption that the instrument is detained in the Eustachian tube.

5. The instrument, on being drawn back, is turned too little towards the Eustachian tube after it has passed its posterior lip, so that the point is in the orifice, but the direction of the beak does not correspond with that of the tube. It may also happen that the catheter, if its beak has not penetrated sufficiently far into the canal, slips out again by its being turned too much outwards and upwards. The point of the instrument is then directed towards the superior pharyngeal wall, which can be seen by the vertical position of the metal ring at its outer end.

5. *Modifications of Catheterization in Cases of Congenital or Pathological Obstacles in the Naso-Pharynx.*

Besides the congenital anomalies which impede the introduction of the catheter, or even make it impossible, obstacles in the naso-pharynx are often met with, due to diseased conditions. The most prominent are the following: The deformities due to traumatic affections of the septum of the nose and of the turbinated bones; strictures of the nasal cavity from ulceration and caries; hyperostosis of the upper jaw (Moos); polypous formations; cancer; sarcoma, and adenoid vegetations in the naso-pharynx; and lastly, often excessive swelling and relaxation of the mucous membrane of the naso-pharynx.

The possibility of introducing the catheter into the Eustachian tube in the presence of such anomalies depends in the first place on the degree of the stricture in the nasal cavity. If, during the introduction of a thick catheter into the nasal cavity, an obstacle is encountered which cannot be overcome by turning the instrument slightly to the side, a smaller catheter must be employed. If this also cannot be pushed forward, the operation must be attempted with a catheter, the beak of which is less curved. Arrived at the place of obstruction, it is not at all advisable to press the instrument forward by force, as not only is unnecessary pain caused, but the nasal walls may also be injured. To evade the obstacle, it is better to turn the beak of the catheter outwards (more rarely inwards) when arrived at the point of obstruction, and at the same time to push the instrument gently backwards. During this manipulation the catheter will often execute a complete rotation round its axis; indeed, cases frequently occur where two rotations of the instrument are necessary to effect a passage through a nose obstructed at several points, and to reach the posterior pharynx. If the obstruction is in the anterior portion of the nose, it can easily be discovered by lifting up the tip of the nose with the left thumb, and by illuminating with the concave mirror first one side of the nose and then the other. It will then often be perceived that the septum of the nose, bulged out strongly at one side, is in contact with the turbinated bones. Tumours and polypoid growths in the anterior and middle portions of the nasal cavity can often also be seen from the front by this illumination. In cases, however, where the narrowing is situated in the deeper portions which cannot be immediately viewed, information regarding the cause and extent of the obstacle may be obtained by Zaufal's specula, by the rhinoscope, or by digital examination.

In case of absolute impermeability of one of the sides of the nose,

it has been recommended to effect catheterization of the corresponding Eustachian tube from the other nasal meatus; and where both sides are impermeable, from the cavity of the mouth. These modifications of catheterism can be quite dispensed with in many cases since the invention of my method, as by this procedure almost the same result is obtained as by catheterization. The above modifications will therefore be used only in exceptional cases where the permeability of the Eustachian tube can be effected neither by the Valsalvan experiment nor by my method, or where the injection of fluids into the middle ear or the introduction of bougies into the Eustachian tube are advisable.

Catheterizing the Eustachian tube from the opposite nasal passage, which was first proposed by Deleau (*Revue Médicale*, 1827), and which is described by Curetti* as a generally applicable method to save the patient the unpleasantness of the introduction of the catheter through both nasal passages, may, in the case of a narrow pharynx, be performed with an ordinary instrument, but can, as a rule, only be accomplished by using a catheter with a beak of from 20-25 mm. in length.† The method of procedure is as follows: After the catheter has been carried forward to the posterior wall of the pharynx, as in catheterizing the same side, its point is turned towards the opposite Rosenmüller's fossa whereby the metal ring at the posterior end of the catheter assumes a horizontal position.

The point of the catheter is then pushed into Rosenmüller's cavity by drawing the outer extremity of the instrument away from the septum of the nose towards the external wall of the nasal cavity; it is conducted into the orifice of the tube by traction over the hard lip of the tube, and is then pushed into the Eustachian canal by a moderate movement backwards.

Fixing the instrument in position, in case of catheterism from the opposite side, is also accomplished most easily with the thumb and forefinger of the left hand, the other fingers being laid upon the bridge of the nose.

The indications for catheterization from the cavity of the mouth, which has been recommended by Störk, Pomeroy, and Kessel, are still more rare than those for the above modification. This operation is only performed when both nasal canals are impermeable to the catheter, or when with impermeability of the one canal catheterization from the other side is not possible. I also use this modification in cases of deficiency of the hard and soft palate,

* *Nuova osservazione di Cateterismo della tuba Eust. destra dalla narice opposta. Gaz. med. italiana Stati Sardi*, 1858.

† The vulcanite catheters can be made very soft by warming them over a flame or in hot water for a few seconds, and they get hard again so quickly, that the beak of the instrument can be lengthened or curved at will in a very short time—a considerable advantage in comparison with the stiff inflexible metal instruments.

whether the orifice of the tube is visible through the gap or not. As the destructive processes in the palate are mostly combined with ulcerations and deformities in the nasal cavity, the tube will generally more easily be reached from the cavity of the mouth through the gap in the palate than through the nose.

The catheters used for this modification are of somewhat thicker calibre. The ordinary curvature of the beak will generally suffice in case of a defect in the palate; with an intact palate the introduction of the tube is effected by placing the catheter flat upon the tongue (which is at the same time pressed down by the instrument), carrying it to the posterior pharyngeal wall and then turning its point upwards and towards Rosenmüller's cavity on the lateral wall of the pharynx. The instrument is at this stage withdrawn till its point arrives at the orifice of the tube, which event is recognised by its being felt to glide over the posterior lip. By a slight movement forwards the beak of the catheter is forced into the Eustachian canal. In those cases in which that fold of the posterior lip of the tube which runs downwards can be seen, the point of the catheter may be carried to the ostium pharyng. tubæ by simply pressing it in front of that fold.

In irritable conditions of the pharynx catheterization per os is not only impeded but even rendered quite impossible on account of the continued choking and vomiting. In such cases the operation is rendered easier by painting the velum palati and the base of the tongue with a 5 per cent. solution of cocaine muriat.

In spite of the frequent congenital or acquired anomalies in the naso-pharynx, the cases where catheterization through the nose is absolutely impracticable, in consequence of mechanical obstructions, are on the whole rare. The insuperable difficulties which occur sometimes in the execution of this operation, even with a normal condition of the naso-pharynx, are much more frequently due to other causes. This is especially true of children, by whom it is almost always energetically withstood. But resistance is met with in the adult also, for not only nervous and old persons but even strong men have an obstinate aversion to this operation, against which all the remonstrances of the surgeon are often powerless. Continued feverishness, weakness, and irritability during the convalescence of sick people of course contra-indicate catheterization.

We will lastly point out a number of unpleasant incidents which may occur during the execution of catheterization, and render success either very difficult or impossible. These are mostly vomiting and a sense of choking in the throat, which occur when the soft palate is touched, but which subside as soon as the catheter is introduced into the Eustachian tube. It happens, however, not unfrequently, that even with the catheter in correct position in the tube, an attack of vomiting is excited; this occurs especially on each occasion that air or fluid is injected into the tympanum. Such choking sensations are most commonly met with in old people, who on the whole do not stand catheterization well, and often do not permit it to be repeated. The rarer incidents by which the operation is interrupted are: dizziness, fainting, continuous sneezing, which ceases only after the removal of the instrument, convulsive attacks of coughing during the introduction of the beak of the catheter into the Eustachian tube, and bleeding from the nose, which occurs, even though the catheter is carefully introduced, in persons predisposed to it.

6. *Methods of Propelling Air into the Middle Ear by the Catheter for Diagnostic and Therapeutic Purposes.*

To Deleau is due the credit of first having made extensive use of this procedure for purposes of diagnosis, but principally in the treatment of the diseases of the ear. He utilized the results of Laënnec's investigations, and, applying them practically, made an important advance in the treatment of ear-diseases.

For the purpose of propelling air into the middle ear, a pyriform india-rubber balloon (capable of holding 350-420 grammes of fluid) is generally used, a force-pump being rarely employed. The air-douche by means of the balloon is executed in the following manner: After the catheter, which has been introduced into the Eustachian tube, is fixed with the fingers of the left hand, and the corresponding ear

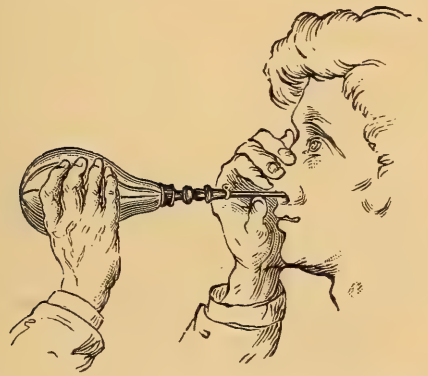

FIG. 77.—AIR-DOUCHE WITH THE INDIA-RUBBER BALLOON.

of the patient has been connected with that of the surgeon by means of the auscultation-tube,* the india-rubber balloon is seized with the right hand in the manner represented in Fig. 77, and is inserted into the outer extremity of the catheter, which fits it exactly, and the air is propelled into the middle ear by compression.

The following precautions have to be observed: The first compressions of the balloon must not be made too rapidly nor with too much force, as should the point of the catheter happen to be pressed against the walls of the pharynx or of the tube, the mucous membrane is injured by a too powerful current of air. The air then penetrates into the cellular tissue of the pharyngeal mucous membrane, and an emphysema results which is mostly confined to the

* This consists of an india-rubber tube about 70 cm. long, to the ends of which are fastened two olive-shaped perforated tips.

pharynx, but sometimes also extends to the entrance into the larynx, as well as to the submucous connective tissue of the lateral region of the neck and face.

The submucous emphysema in the pharynx, which is mostly caused by careless use of the catheter, or through forced bougieing, generally disappears after a few days. It is most troublesome during the act of swallowing, and respiration is somewhat impeded only when the swelling is of considerable extent. Often a continuous, troublesome tickling and itching in the pharynx will arise, which cause the patient to clear the throat repeatedly, whereby the emphysema frequently increases in extent, because by the forced acts of expiration air is driven below the mucous membrane at the injured point. It is therefore important to recommend patients, after the occurrence of emphysema, to suppress as far as possible the clearing of the throat and the act of swallowing. If the swelling assumes such an extent that it produces difficulty in breathing, an exit for the air may be made by tearing the pharyngeal mucous membrane with the nail of the forefinger, or, according to Guye, by cutting the soft palate with scissors. In cases of emphysema affecting the cheeks and the neck, friction of the parts has been recommended—but is not, in my opinion, a good method of treatment, for it drives the air towards the pharynx, rather increasing the disorder.*

If, therefore, on compression of the balloon great resistance is felt, it is advisable to draw back the instrument a little, whereby, as a rule, the orifice of the catheter is rendered free and the air can penetrate unchecked into the canal. In order to avoid such obstacles, which are caused by the catheter being improperly fixed, it is advisable before each compression of the balloon to slightly approximate the catheter to the balloon with the thumb and forefinger of the left hand, to counteract the backward movement of the instrument consequent to compression. To avoid the blow of the balloon upon the catheter, it may be connected with the catheter by means of a short piece of india-rubber tubing.

The most powerful action of the balloon is obtained when, as in Fig. 77, it is fixed by the thumb and palm of the hand, and compressed from the side by the four fingers. On the other hand, the pressure is considerably less when the fingers are applied round the neck and the balloon is compressed by the thumb laid at its base. Hartmann obtained a pressure of 388 mm. Hg. by the former method and only 260 mm. Hg. by the latter.

The air being heard to enter the middle ear freely, the subsequent compressions, 5-6 in number, should be rapidly and powerfully carried out. On this chiefly depends the therapeutic value of the air-douche. After each compression the balloon requires to be removed from the catheter so that it may again be filled with air.

To avoid the removal, balloons with valves have been constructed, but experience shows that they soon get out of order. Perforated balloons have

* The extension of the emphysema to the cavum tympani and membrana tympani (Schwartze) and to the mastoid process is one of the most rare occurrences.

also proved unsuitable, because the orifice by frequent use very soon becomes dilated. Bellows and treadle-balloons which were formerly, and even again recently, recommended, have gained no place in practice, as even with large bellows only an insufficient pressure is produced.

Although this mode of inflation suffices in the majority of cases requiring the air-douche, it unfrequently occurs, however, that the resistance in the Eustachian tube and in the tympanic cavity cannot be overcome by it, or, if the air enters into the middle ear, the current is so weak that it is necessary to use a force-pump.

My force-pump (Fig. 78) consists of a globular metal receptacle, 14 cm. in diameter (*e*), in which the air is condensed by a piston, working in a tube (*d*).

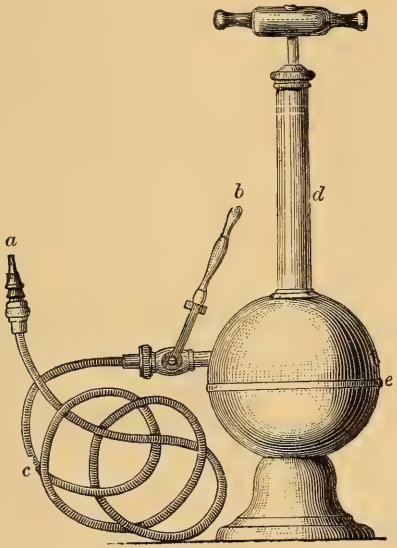

FIG. 78.—FORCE-PUMP.

The difference of this pump from its predecessors is, that its manipulation does not require the least exertion, that the compression of air in the pump to the necessary degree can be accomplished in a very short time and with only one hand, and that the strength of the escaping current can be exactly regulated. A double-acting valve renders it possible, by a rapid upward and downward motion of the piston, to increase the pressure to $\frac{2}{3}$ atmosphere in the space of fifteen seconds. Considerable advantage is gained in this pump by the lever-valve (*b*) fitted on the escape-pipe. By it the strength of the current of air can be fixed according to the size of the angle formed by the lever with the vertical; also, if a powerful current of air, of short duration, is to be applied, it can be instantaneously interrupted by a rapid backward and forward movement of the lever. The india-rubber tube (*c*), connected with the escape-pipe, is furnished with a conical nozzle (*a*), which is fitted into the outer extremity of the catheter.

To determine the pressure of air in the pump, an open or closed quicksilver manometer, or a spring one, may be connected with the escape-pipe behind the valve. In force-pumps not provided with a manometer, the pressure may be measured by testing with a manometer the number of motions of the piston required to produce $\frac{1}{4}$, $\frac{2}{5}$, $\frac{1}{2}$, and 1 atmospheric pressure.

Before the compressed air is allowed to pass through the catheter into the tympanic cavity, it is necessary to ascertain by the use of the balloon that the catheter is correctly placed in the Eustachian tube. If this precaution is disregarded, serious accidents may happen, as the mucous membrane of the tube or of the naso-pharynx may be injured by the rapid entrance of a current of air, giving rise to extensive emphysema of these parts. For besides the pain, choking sensations in the throat, and dyspnœa, suffocative attacks may occur if the emphysema spreads downwards to the entrance of the larynx.*

The double balloon, which was recommended by Lucae and Schwartz, may be used in those cases in which only a small pressure is required, but its therapeutic value will be found to be much less than the simple air-bag. I must, however, modify my former statements somewhat in this respect, that with the new larger double balloons much better results may be obtained than with the small ones formerly used. The strength of the current of air with the double balloon can be increased by compressing the tube as well as the balloon when filling the latter, and further by forcibly compressing the latter as the air is leaving it.

The assumption that a constant current of air can be kept up with the double balloon is not quite correct, since at each compression of the balloon a variation in pressure arises. Lucae (*A. f. O.*, vol. xx.) recommends Munck's water-bellows for the purpose of creating either a constant or interrupted current. This instrument may easily be made use of in clinical institutions, but the construction is too expensive and complicated for private practice.

Blowing air into the catheter with the mouth, still practised by many specialists, is only to be employed in exceptional cases; for, apart from the fact that the expiration-force is mostly too weak to be of therapeutic value, the majority of patients are reluctant to be operated on in this manner.

Results of Auscultation in Normal and Pathological Conditions of the Middle Ear.

The signification of auscultation for the diagnosis of middle ear affections is very often over-estimated, and, on the other side, too often under-estimated. Although auscultation very often gives a negative or indefinite result, in certain cases it gives conclusive diagnostic evidence. It can only be relied upon in connection with other symptoms. If air is propelled into the normal middle ear by the catheter, the listener will hear a large,

* In two cases of Turnbull's of London, where sudden death occurred during the application of the force-pump, the fatal cause remained unexplained. It is quite probable that the entrance of the larynx was closed up by a considerable submucous emphysema, and that death from suffocation ensued.

dry, protracted, blowing sound, similar to that which is produced if the tongue is brought near the hard palate and the act of expiration is performed quickly while the lips are almost closed. But the flapping sound, which is noticed during the Valsalvan experiment, is rarely perceived. This blowing sound (Deleau's *bruit de pluie*), which is caused by friction of the air on the walls of the Eustachian tube and of the tympanic cavity, and receives its peculiar character mainly from the friction of the air on the inner surface of the membrana tympani, has various degrees of strength and distinctness, which are dependent on the varying width of the Eustachian canal in different individuals.

The calibre of the catheter, the size of the orifice at its point, and its position with regard to the walls of the Eustachian tube, exercise a considerable influence on the pitch and the intensity of the auscultation-sounds, in the normal as well as in the diseased ear.

By using slender catheters, a higher and shriller sound will generally be heard than by propelling air through a catheter with a wider lumen. A change of the auscultation-sound may also occur during catheterization, if the orifice in the beak of the catheter is relatively narrowed by lying against the wall of the tube through a change in the position of the instrument.

It has already been insisted that the Eustachian tube is widened by the act of swallowing so that it gapes. Thus the air propelled through the catheter during the act of swallowing is heard to enter the tympanum with a much louder noise. It is consequently better, in order to increase the therapeutic effect, to have the patient swallow repeatedly during the catheterization.

This presence of a distinct sound of air entering during the act of swallowing does not justify the conclusion that the catheter is properly inserted in the Eustachian tube, since even when the point of the catheter is situated either before or behind the orifice of the tube, air may enter the cavum tympani through the tube, which, as before mentioned, opens during swallowing.

The current of air, which in pathological cases occasionally reaches no farther than the isthmus tubæ, produces a sound which bears a remote resemblance to that caused by air entering the cavum tympani, and consequently may be easily mistaken for the latter by practitioners of no great experience. The difference, however, is that the former is much weaker and softer, and seems far more distant than the latter, which is heard as if it arose immediately under the ear of the examiner.

In some cases, mostly pathological, in which no sound is heard in spite of the entrance of the air into the cavum tympani, I use the ear manometer (Fig. 61) designed by me, which is inserted hermetically into the external meatus, to ascertain whether air has entered the cavity. Every time the

inflating-bag is compressed and air enters into the tympanic cavity, the drop of fluid with which it is supplied will rise, owing to the bulging forward of the membrana tympani.

The normal auscultation-sound caused by the use of the air-douche is subject to many changes in diseased states of the middle ear. To estimate the value of these abnormal sounds, we must bear in mind that we have to deal generally with a combination of sounds, caused partly by free exudation in the middle ear, partly by swelling of the lining membrane of the middle ear and stricture of the Eustachian tube, and partly by morbid changes in the membrana tympani. That the strength of the air-current influences the quality of the sounds need hardly be mentioned.

There is usually a considerable difference between the auscultation-sounds produced in cases of perforate membrana tympani and those in cases in which the membrane is intact. When the membrane is not perforated, the sounds heard on auscultation vary directly with the amount of swelling and secretion in the middle ear. In cases of accumulation of secretion in the middle ear, rattling noises, differing in quality, will frequently be heard whilst the air-douche is being used. These rattling noises originate most frequently in the Eustachian tube, especially when it contains rather fluid secretion. They are less frequently due to the passage of the air through accumulations of secretion in the tympanic cavity. But if a considerable quantity of fluid secretion has collected, such sounds will often arise in rapid succession, may even be heard without the auscultation-tube, and frequently continue for some time after the inflation; while, with a scantier secretion, the presence of which can be proved by inspection of the membrana tympani, frequently no such sounds will be heard.

In the case of a secretion of fluid consistence there is generally heard a râle of a fine bubbling character; on the other hand, in the case of thick, tenacious secretions, the sound has a larger, uniform, and more interrupted bubbling character, the interruption sometimes having the character of a rough friction-sound, caused by a simultaneous swelling of the mucous membrane of the tube and an alteration in the tension of the membrana tympani. A distinct râle is often heard only at the commencement of the inflation, soon followed by a rough or freer inflation-sound if the secretion lodged in the tube has been removed by the first inflation of air, or if during the introduction of the catheter mucous secretion from the naso-pharynx has stuck to its point and got into the tube with the beak of the instrument. This occurs frequently, and may give rise to mistakes, because the rattling sounds so caused might be looked on as a consequence of hypersecretion of the mucous membrane of the tube.

The rattling sounds produced by mucus in Rosenmüller's cavity or near the orifice of the tube, when the catheter is incorrectly placed, must be distinguished from those already described. As has long been known, it differs from the sounds produced in the middle ear in that it resembles the bursting of large bubbles, and is heard as if distant from the ear. Grating sounds are also observed in the pharynx during the application of the air-douche, caused partly by vibrations of the membranous wall of the tube, partly by the vibration of the soft palate when the air is returning.

That the friction of the air on the inner surface of the membrana tympani gives the particular character to the auscultation sound is proved in cases of anomalous tension of the membrana tympani. Especially when the membrana tympani is relaxed from cicatrices, as a consequence of atrophy of the membrane, or when there is cicatricial adhesion between the membrane and the inner wall of the cavum tympani, even when the passage through the Eustachian tube is normal, a sharp, high, vibrating sound is produced, which appears to be so near the ear of the auscultator that it may easily be mistaken for the auscultation sound in perforation of the membrana tympani.

When auscultation is doubtful in these cases it can be decided by use of the ear manometer. Where there is no perforation the fluid only rises in the tube, but where the membrane is perforated the fluid will be expelled from the tube.

In inflammations of the middle ear without swelling or secretion the auscultation-sounds vary. If the tube and the membrane are not affected, as is the case in the circumscribed inflammations of the middle ear, which cause stiffness of the ossicular articulations, but more commonly anchylosis of the stapes, the normal blowing-sound will always be heard. In cases of more general thickening of the mucous membrane of the middle ear, however, where the membrana tympani is also drawn inwards, there will be heard only a weak, dry, thin sound, or sometimes a high, shrill or whistling one.

The character of the auscultation-sound in a case of perforated membrane depends on the presence and quantity of secretion in the middle ear, on the degree of stricture of the Eustachian tube, and also on the size of the perforation. Either a hissing sound combined with a rattling, perceptible even without the auscultation-tube, or, where there is scanty secretion and a strictured tube, a high-pitched whistling or hissing sound without any rattling is heard. If the tube is dilated, which occurs after suppurative inflammation of the middle ear, a blowing, puffing sound will be perceived, even if the perforation in the membrane is small. As the air which comes through a perforation passes into our ears through the auscultation-tube, these sounds will be heard as intensely as if they had their origin in our own ear. In cases where the margins of the perforation lie closely together, where also inspissated purulent masses, growths of mucous membrane in the tympanic cavity, or adhesions closing the tympanic orifice of the Eustachian tube cause obstruction to the air entering the cavum tympani no perforation sound may be heard.

Concerning the auscultation of the mastoid process, Laënnec* has already proved that the air entering into the middle ear produces a sound in the mastoid process, plainly perceptible by auscultation, and that also rattling sounds in the middle ear are heard by auscultation at the base of the mastoid process, and the locality of their origin can be distinguished. According to Dr. Michael† if a blowing auscultation-sound is heard in the mastoid process of the living, it can be positively asserted that the mastoid cells are filled with air and are therefore free from any pathological products. When

* *Sur l'Auscultation médiate*, 1835, p. 57.

† *Arch. für Ohrenheilkunde*, vol. xi., p. 46.

the permeability of the Eustachian tube is much impaired, as well as when there is perforation of the membrana tympani, no sound whatever will be perceived in the mastoid process. If these two conditions can be excluded and the sound be absent, a diseased state of the mastoid cells may be inferred (*e.g.*, exudation, cheesy masses, growths of mucous membrane, sclerosis).

7. *Methods of Injection of Fluid and of the Introduction of Vapours into the Middle Ear through the Catheter.*

Injections of fluid through the catheter are employed in the different forms of disease of the middle ear. Their purpose is: (1) in swelling and hyper-secretion, by the immediate action of the medicated fluid upon the diseased mucous membrane, to lessen the secretion, and to cause a decrease in the swelling of the lining membrane; (2) in that form of disease in which, in consequence of condensation of the mucous membrane, a firm union of the ossicula with each other and with the walls of the tympanic cavity exists, to effect an irritation and loosening of the rigid mucous membrane, and thereby a greater mobility of the ossicula, by the injection of slightly irritating fluids; (3) in accumulation of inspissated secretions, to bring about their removal by liquefying them.

The quantity of the fluid penetrating into the tympanic cavity is the greater the farther the point of the catheter is pushed towards the isthmus tubæ, and the more exactly the orifice of the instrument corresponds with the direction of the Eustachian tube. In no case is it possible to judge accurately what quantity of the injected fluid has reached the cavum tympani, since on account of the funnel shape of the tube and the bend in the canal at the isthmus a partial escape of the fluid cannot be prevented.

The details of the method of injection of small quantities of fluid into the middle ear, as at present in use for purposes of treatment, are the following: After the catheter has been introduced into the Eustachian tube, air is injected two or three times into the tympanic cavity by means of the inflating-bag to remove secretion, which might be deposited in the tube, and would obstruct the entrance of the fluid.

Next 6-8 drops of the slightly warmed medicated fluid are put into the catheter by means of Pravaz's syringe, and the fluid is blown into the middle ear by the balloon. Care must be taken that the head of the patient remains in the erect position, because if the head is inclined backwards, the fluid in the catheter will escape into the pharynx before the propulsion into the middle ear has taken place.

When the membrana tympani is imperforate a sharp sound will be heard as it enters the ear accompanied by a fine crepitation which may often be heard for some time after the injection. The inspection of the membrana tympani will show either an unaltered state of the membrane, or a more or less marked injection of the vessels of the handle of the malleus, and great

congestion of the neighbouring portions of the superior and posterior walls of the meatus; this occurs not only with the application of irritating injections, but also sometimes with the employment of quite indifferent fluids. Small quantities of fluid are seldom seen after injection to shine through the membrana tympani; large quantities of fluid will, however, be seen to shine through, especially when the membrane is transparent, and the fluid is coloured.

The subjective symptoms which occur after inflation consist mostly of a sensation of fulness and warmth, sometimes of burning, more rarely of acute pain in the ear and a passing sensation of taste (Moos). I have seldom observed great reaction with subsequent inflammation in the middle ear, and never an inflammation with suppuration in the tympanic cavity, and perforation of the membrana tympani. Frequently the escape of a portion of the fluid into the pharynx causes an unpleasant itching, hawking, and cough, which can be most quickly removed by gargling with cold water. Acute pain in the ear after the injection is removed, either by rubbing the region of the external ear, by simply breathing into the ear, or by pouring lukewarm water into the external meatus.

For the injection of larger quantities of fluid into the middle ear a thicker catheter with a longer beak is used, and is pushed as far as possible into the Eustachian tube. The injection is effected by a vulcanite syringe, made to contain 80-100 grammes, the nozzle of which can be fitted hermetically into the outer extremity of the catheter. The greater the resistance in the middle ear, the more difficult is the injection of fluid into the tympanic cavity; indeed, even with a permeable tube and a perforated membrane, and with the point of the catheter well pushed in, only a portion of the injected fluid will escape at the external meatus, the greater portion making its way into the pharynx or the nose.

In cases in which the cavum tympani is either partially or wholly filled with inspissated secretion or by proliferation of the mucous membrane, so that the injected fluid cannot force its way into the cavum tympani, but flows back into the pharynx instead, it is advisable to use the elastic tympanic tube recommended by Weber-Liel. I have found this instrument, which was originally intended for sucking exudation out of the cavum tympani and for injection of medicated fluids into the tympanum, invaluable in the treatment of certain diseases of the middle ear, external meatus, and mastoid process, and almost indispensable in the practice of disease of the ear.

The tympanic catheter (Fig. 79) consists of a small flexible tube, funnel-shaped at its outer extremity, 17 cm. long, and 1-1¼ mm. thick, with a small aperture at its point (or on its side) for the exit of air or fluid.

The introduction of this tube into the tympanic cavity is effected in the following manner: a moderately thick vulcanite catheter, 12 cm. long, through which the small catheter can easily be pushed, is first introduced into the Eustachian tube. The point of the small catheter will be in the

tympanum, when it has been pushed 2½-3 cm. beyond the point of the catheter, as indicated by a mark previously made on its outer extremity. Inasmuch as the catheter is held in position by the tympanic tube, Delstanche's clamp is unnecessary for fixation.

According as a smaller or larger quantity of fluid is to be injected, either Pravaz's graduated syringe or a larger one is used, and its nozzle must fit into the funnel-like widened extremity of the tympanic catheter. As the friction of the fluid in the latter is very great, a considerable amount of pressure has to be employed during the injection; this pressure must be increased only gradually, because if outflow into the external meatus is prevented, violent pain and giddiness may arise from the suddenly increased pressure of the injected fluid upon the walls of the tympanum.

Fig. 79.—Elastic Tympanic Catheter.

When the fluid injected either by the catheter alone or by aid of the tympanic tube is entering the tympanic cavity, a dull rushing sound will be heard similar to that which is perceived when one listens over an india-rubber tube through which fluid is flowing. When a considerable quantity of fluid is injected, although the tympanic catheter has been used, a large portion will flow into the naso-pharynx.

The injection of large quantities of fluid into the middle ear by the catheter as well as by the tympanic tube I consider applicable only in those affections of the ear where a perforation of the membrana tympani exists, and where, therefore, the fluid injected into the tympanic cavity may escape again through the external meatus. Referring to the special division for the indications for this method, we will here only mention that injections of warm water are specially serviceable when there is violent inflammation in the middle ear in consequence of inspissated secretion, and where liquefaction and removal of the inspissated exudation have to be effected. They are also successfully employed in those cases where, in the course of chronic suppuration of the middle ear, even without retention of secretion, an acute inflammation is intercurrent, accompanied by violent pain and with or without an osseous affection.

We must, however, disapprove of such injections in those affections of the middle ear in which the membrana tympani is not perforated. Deleau,* and Bonnafont,† speaking from considerable experience, have already pointed out the injurious consequences in the middle ear which follow the injection of large quantities of fluid when the membrana tympani is intact, for, after the introduction of a large quantity of fluid into the middle ear, there is not unfrequently a most violent reaction, accompanied by the development of a very painful suppurative inflammation of the middle ear, with perforation of the membrana tympani, which may lead to fatal complications.

* *Traité du Cathétérisme de la Trompe d'Eustache*, p. 53.

† *Traité théorique et pratique des Maladies d'Oreille*, 1860, p. 77.

The method of introducing bougies into the Eustachian tube will be described in the treatment of stricture of the tube.

The introduction of medicated substances in the form of vapour in the treatment of the diseases of the middle ear was formerly practised more frequently than now. The volatilizers proposed by Itard, Kramer, Lincke, Wolf, Rau, and others, have almost all gone out of use, and at present, in the rare cases in which vapours are introduced into the middle ear, more simple instruments are employed, of which the one designed by v. Tröltsch is the most practical, on account of its compendious form and easy production. This apparatus consists of a glass bottle with a wide neck, closed by a stopper of vulcanized india-rubber pierced with three holes, and fixed on a stand. Into the middle orifice is inserted a thermometer to ascertain the temperature of the vapours, in the lateral orifices two curved glass tubes; the one serves for the conduction of the compressed air, and the other with a rubber tube attached is for the introduction of the vapour into the tympanic cavity. The steam is produced by means of a water or sand bath heated with a spirit-lamp.

For the application of sal-ammoniac vapour 'Kerr's Inhaler,' as modified by me, is to be recommended. This apparatus (Fig. 80) consists of a glass bottle holding $\frac{1}{4}$ litre filled about one-third full of water, with a broad india-rubber stopper having a large and a small opening in it. The straight leg of a Y-shaped glass tube is passed through the larger opening in the neck of bottle, and is immersed into the water contained in the bottle (*t*, Fig. 80), a thin rectangular tube being passed through the smaller orifice so as not to reach the surface of the water. If a longish piece of asbestos, which has been dipped into hydrochloric acid, be now suspended in the arm, *n*, of the Y-shaped tube by means of a thin wire, and a small sponge saturated in ammonia be similarly placed in the other arm, *a*, when the air contained in the glass vessel is sucked out through the rectangularly bent tube, *m*, the vapours of hydrochloric acid and ammonia will unite to form sal-ammoniac in the lower section of the tube, which passing through the water may be inhaled in a purified form.

The apparatus so frequently used for the inhalation of chloride of ammonium vapours in the treatment of laryngeal and bronchial catarrh is employed by many English aural surgeons (Dalby, Urban Pritchard), more especially in cases of dry catarrh of the middle ear, in such a manner that the vapour taken into the mouth is further forced into the middle ear by means of Valsalva's method. I cannot, however, recommend this method, for it enables only a small portion of the vapour to be introduced into the middle ear, and furthermore, one possesses all the disadvantages of Valsalva's method (*vide* following section).

The above-mentioned apparatus is modified in the following manner for the purpose of introducing sal-ammoniac vapours into the middle ear by means of a catheter. The two ends of a bifurcated glass tube, *g*, the stem of which is attached to a double balloon, are connected by means of short pieces of india-rubber tubing with two bent glass tubes, *r*, *r*, each of which carries a perforated rubber stopper at its other extremity, these stoppers being accurately fitted into the glass tubes *a*, *n*. On pressing the double balloon,

vapours of hydrochloric acid and ammonia are forced into the lower section of the Y-shaped tube, where they unite to form sal-ammoniac vapour, which being purified in its passage through the water may now be conducted through a rubber tube, *s*, and catheter, *c*, into the cavum tympani.

In all the apparatus for the injection of vapours, the impregnated air leaves the nozzle of the catheter with far less energy than is the case with the ordinary air-douche. The pressure being thus so slight, the vapours can only reach the tympanic cavity provided the tube be permeable. In cases in which the tube is much swollen both the simple and double balloons will be

FIG. 80.—APPARATUS FOR CHLORIDE OF AMMONIUM VAPOUR.

insufficient as a compression apparatus, and recourse must be had to the force-pump. Perforation of the membrana tympani greatly facilitates the entrance of vapours into the middle ear.

The temperature of the vapour will vary with the nature of the medicaments employed, some of which volatilize at a low, others at a high, temperature. The duration of the injection depends likewise on the nature of the drugs employed and upon the amount of irritation which is developed during the action of the vapour in the ear or pharynx. Generally the time of the application varies from 3-10 minutes.

When applying rapidly evaporating fluids such as sulphuric ether, acetic

ether, ethylic iodide, chloroform, turpentine, etc., a volatilization apparatus is not required. In such cases the simple rubber balloon as used for the air-douche is sufficient, the vapours being collected by placing the point of the compressed balloon into the small bottle containing the medicated fluid (not into the fluid), and then gradually relaxing the pressure.

The introduction of vapours into the middle ear is accompanied by a feeling of warmth and fulness in the ear. Great burning or a stabbing pain with, at the same time, injection of the vessels along the handle of the malleus, occurs most frequently after the action of ammonia vapours. The escape of vapours into the naso-pharynx often causes great itching, hawking, coughing, congestion, and swelling of mucous membrane with increased secretion.

Far smaller quantities of the vapours passed through the catheter reach the middle ear than was formerly supposed. This is equally true for simple steam, or that impregnated with drugs, and for ammonia vapours which are precipitated at the isthmus tubæ, more especially in cases of injection of the tube, although larger quantities enter the tympanic cavity when the tube is readily passable. On the other hand, the finely divided vapours of the various forms of ether, chloroform, turpentine, and likewise carbonic acid as recommended by Reute and Rau, and hydrogen as recommended by Löwenberg, may be easily propelled into the middle ear, even when there is considerable obstruction in the Eustachian tube.

c. The Author's Method of making the Eustachian Tube Permeable. (Politzer's Method.)

The method of making the Eustachian tube permeable, which I published in 1863,* is based upon the fact that the air in the naso-pharynx, when closed on all sides, becomes condensed during the act of swallowing, and is thereby forced through the Eustachian tube into the middle ear. The essential novelty of this method, by which it is distinguished from catheterization of the Eustachian tube, lies in the fact that the nozzle of the instrument to be used for condensation of air is introduced only into the anterior portion of the nasal cavity, and thereby introduction of the catheter into the Eustachian tube, which is sometimes impracticable and often disagreeable, is avoided. The closure of the naso-pharynx in this method is effected, behind by the soft palate being closely applied to the posterior pharyngeal wall, and in front by compression of the alæ of the nose. At the same time the resistance in the tube is lessened by the act of swallowing, by which the influx of the condensed air into the tympanic cavity is materially facilitated.†

* *Wiener med. Wochenschrift*, 1863, No. 6.

† This method was suggested by a number of experiments made in reference to the fluctuations in the pressure of air in the tympanic cavity. I quote here the second experiment (*W. med. W.*, 1863, v. 6), which I demonstrated to Professor v. Tröltsch

The most serviceable instrument for my method is a pyriform balloon (Fig. 81), about the size of the doubled fist (10-12 oz.), which is furnished with a slightly curved tubular nozzle. To avoid bleeding, which is frequently produced by the immediate impact of the stiff nozzle upon the pituitary membrane, the connection between the balloon and the nozzle is effected by the insertion of a short elastic india-rubber tube. For some years past I have used in my practice the rubber balloon (p. 101) which is usually only employed for catheterization, its nozzle being provided with a somewhat rigid india-rubber tube $3\frac{1}{2}$ cm. long (Löwenberg).

The details of the method are the following: The patient, being seated in a chair, takes a little water into his mouth—to facilitate

FIG. 81.—POLITZER'S METHOD.

swallowing—which he is required to swallow when told.* The surgeon, standing on the patient's right, or in front, introduces the nozzle of the Politzer-bag one cm. into the nasal orifice of the cor-

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in 1861. If I introduce the extremity of the escape-pipe of a force-pump into the nose, half an inch deep, and compress the alæ round it, and then perform an act of swallowing while the compressed air rushes into the nasal cavity, I feel the air at the same moment entering with force into both tympanic cavities, while the drop of fluid in a manometer, inserted into the external meatus, moves outwards.

* The use of water is by no means absolutely necessary in all cases during the application of my method, which I often perform during a simple act of swallowing, the effect of an energetic act of deglutition being the same as that of drinking water. Sometimes, however, the simple act of swallowing is less powerful, and not only is deglutition in such cases materially facilitated by drinking water, but the lumen of the Eustachian tube is also more widened by the powerful contraction of the naso-pharyngeal muscles, and the effect of the injected air is increased. Miot gives the patient a small piece of sugar instead of water, by which salivation is produced, facilitating the act of swallowing.

responding side at its posterior angle, and then compresses with the left thumb and forefinger the alæ of the nose closely round the instrument. The patient is next told to perform an act of swallowing, and at the same moment the surgeon expels the air from the inflating-bag with his right hand. By the condensation of air, produced in the naso-pharynx in this manner, the air is forced into both middle ears, the closure effected by the soft palate is forced open, and its vibrations give rise to a dull gurgling noise which frequently, if not always, may be taken as an indication that the air has entered into the middle ear.

The majority of patients experience at the same time the subjective sensation of a stream of air entering both tympanic cavities, but the sensation may be entirely absent, even in persons who have normal sensibility of the mucous membrane of the middle ear, as well as those in which the sensibility is impaired. Children who are suffering from catarrh of the tube will be seen to put the hands up to their ears at the moment when air enters the cavum tympani (Pagenstecher). The bulging of the membrana tympani will generally be seen to be more than by the Valsalvan method or by catheterization. The effect is most pronounced upon the membrana tympani when there is either total or partial retraction, as the retracted part will be bulged out, sometimes even in the form of a bulla.

The results of auscultation during the author's method may be summarized as follows: That even with an intact membrana tympani, in spite of the gurgling noises in the pharynx, the sounds which have been produced in the middle ear can be plainly distinguished, as by continued practice we are enabled to disregard the more distant pharyngeal noises, and to concentrate our attention upon those nearer ones.

During the application of my method we will therefore often hear the bulging-out noise of the membrana tympani (Moos) and the abnormal auscultation-sounds which were mentioned during the description of the operation of catheterization. While, however, during catheterization the noise appears modified by the friction of the air in the catheter and by its escape from the point of the instrument, the auscultation-sound during the application of my method, where these disturbances are absent, is comparatively often more clearly heard. When there is perforation of the membrana tympani the escape of air through the external meatus can even be heard without an otoscope.

Where the inspection gives a negative result after the entrance of air into the middle ear it may be proved by using the ear manometer in the external meatus, provided with coloured fluid as previously described (*vide* p. 64).

The air, condensed in the naso-pharynx by my method, will as a rule enter into both tympanic cavities, more powerfully, however, on the side where the resistance in the tube and in the tympanic cavity is feebler. Therefore to concentrate the effect of the current of air upon the diseased ear, when only one is affected, and to hinder

the entrance of air into the normal one as much as possible, it is necessary to create an artificial resistance in the latter by hermetically closing its meatus with the finger. In cases in which both ears are affected, the same measure may be adopted; as for instance when, owing either to perforation of the membrane or to diminished resistance in the Eustachian tube, the entrance of air into one ear takes place more readily than into the other. In such cases, where we wish to inflate the latter more powerfully, the meatus of the former must be hermetically closed with the finger. Indeed where both ears are affected, and the current of air penetrates equally strongly into both cavities, the mechanical and therefore also the therapeutic effect of inflation can be increased by closing the meatuses alternately, to allow the full power of the air-current to act separately upon each tympanic cavity.*

The strength of the air-current to be employed depends generally on the amount of resistance in the middle ear, on the presence of inflammatory phenomena, and also sometimes on the pathological changes in the membrana tympani. In the case of slight obstacles, which may be assumed when the hearing-power has not been much diminished, and also in acute inflammations of the middle ear, where the reactive phenomena, especially the pain, have not completely disappeared, currents of slight pressure are advisable. For this purpose the introduction of air may be effected either by the mouth, by blowing through a short india-rubber tube, or by the balloon, in the application of which the pressure by using two, three, four, or five fingers can be regulated so that the air will enter the cavum tympani either with a mild or strong pressure as wished. In cases of great resistance, however, the permeability of the Eustachian tube must be effected by powerful and rapid compressions of the balloon or with the double balloon. The air-pressure needed for my method varies from 0, 1-0, 4 atmospheres and above.

The effect of inflating with air after the author's method depends on the nature of the pathological changes which impair the function of hearing. In those affections of the middle ear where, in consequence of swelling and accumulation of secretion, and of the abnormal tension of the membrana tympani and of the ossicula combined with it, a high degree of deafness often exists, a striking improvement in the hearing will generally follow the application of my method; where, however, in the course of inflammatory processes in the middle ear a development of newly-formed connective tissue, and thereby abnormal anchylosis of the ossicula with each other and with the walls of the tympanic cavity have taken place, or in deafness from

* Löwenberg recommends for this purpose a balloon fitted with a side tube for the meatus.

nervous origin, either no improvement in the hearing or only a slight one is effected by this method. The feeling of improvement in the hearing will often correspond with a demonstrable increase in the hearing-distance; however, cases are not unfrequent where the patients complain after the application of my method of a feeling of numbness in the ear, while by testing, a considerable increase in the hearing-distance is ascertained.

The sensation of pressure in the region of the stomach which sometimes occurs immediately after the employment of my method is chiefly observed as the result of considerable pressure applied by means of the force-pump, more seldom seen after the use of the balloon. This sensation is caused by the abrupt entrance of air into the inferior portion of the œsophagus, but it may very quickly be removed by making the patient take several deep breaths in succession. Other accidents which rarely occur by the use of my method are dizziness, sense of fulness in the head, and pain in the forehead. Rupture of the membrana tympani, which also occurs by Valsalva's method and catheterization, occurs very seldom by my method when carried out by swallowing or during phonation. The rupture occurs mostly in those membrana tympani which are either atrophic, thinned by cicatrization, or contain deposits of chalk.* Such ruptures, according to the observations of Pagenstecher, Schwartze, von Horck, Gradenigo, and myself (Wiener, *Med. Presse*, 1868), are followed by no bad results, but in fact by a noticeable improvement in hearing which generally remains. If one wishes to guard against a rupture of the membrane during the use of the air-douche it is best to close the external meatus by means of the finger.

My method has in the course of years been modified, partly by myself and partly by others, and the original indications have been increased. It is worthy of special notice that the effect of this method is not confined to the middle ear alone, but that secretion in the naso-pharynx, and even in the cavities adjoining the nose, is removed by the air-current (Hartmann). The modifications refer partly to an alteration in the form of the instrument, partly to the closure of the soft palate.

The modifications of the form of the instrument have for the most part proved impracticable. Olive-shaped nozzles, even when tightly fitted into the nostrils, cannot prevent the reflex of air from the nose. Long tubular nozzles (Grazzi) diminish the strength of the pressure. Still less useful was the application to both nasal orifices of a plate pierced with two holes, as proposed by Allen. The substitution for the hard nozzle of a short india-rubber tube (Löwenberg), however, appears to me very serviceable, because the painful sensation which is produced by the compression of the nasal wings round the hard nozzle as well as the occurrence of bleeding from the nose are avoided. The employment of a short elastic nozzle is also recommended on the ground of cleanliness, as each patient can be provided with a separate tube, thus excluding completely the possibility of infection. The manipulation of this nozzle, however, requires a certain amount of practice, inasmuch as complete compression of the india-rubber tube must be avoided when

* The normal membrana tympani can be ruptured by a pressure of 3-4 atmospheres (Schmiedekam). In practice, however, we seldom use a pressure of more than ½ atmosphere.

pressing the alæ of the nostrils together, and on the other hand, the escape of air past the tube and through the nasal orifices must be prevented.

Regarding the various proposed modifications of the method of closing the soft palate, it was first proved by Schwartze* that, especially in children, air can penetrate to the middle ear by applying the author's method even without the act of swallowing. The reason for this is to be found partly in the narrowness of the naso-pharynx and in the shortness of the Eustachian tube in the child, partly in the fact that the soft palate is reflexly lifted up by the action of the current of air on its upper surface, is applied to the posterior pharyngeal wall, and closes the naso-pharynx downwards. Löwenberg † found that the act of swallowing during the application of my method may be replaced by a simple lifting of the soft palate. I observed myself in patients who began to speak at the moment of compression of the balloon, that the compressed air in the naso-pharynx was forced into the cavum tympani. Based upon the fact, which was proved experimentally by Czermak and Brücke, that during the phonation of both vowels and consonants the soft palate is applied to the posterior pharyngeal wall, Lucae proposed (*Virch. Arch.*, vol. lxiv., 1875) to substitute the vowel *a* in place of the act of swallowing in my method. Several weeks after the publication of Lucae, Jos. Gruber in Vienna (*Allg. Med. Zeitung, u. M. f. O.*, 1875) proposed in place of the vocal *a* to use the syllables *hik* and *huk*, and sought to establish the fact that he had discovered a new method, an imputation which was refuted by Lucae (*Canstatt, Jahresbericht der ges. Med.*, 1875, vol. ii., p. 505). Holt, Tansley, and Lewi inject the air while the patient forcibly puffs out the cheeks, whereby the soft palate is forced against the wall of the pharynx by the pressure of expiration and the naso-pharynx is shut off from the lower portion of the pharynx. That all these propositions are not new methods, but modifications of the original, is self-evident, and are insufficient in most cases for the closure of the soft palate.

A modification of the original method, which I proposed, is very useful in practice, and consists in this, that while the air is being forced into the naso-pharynx the patient inspires through the nearly closed lips or through a short piece of rubber tube held between the lips. By this means the naso-pharynx is closed, and at the same time the canal of the Eustachian tube is widened by the traction of the soft palate backward. Although in general this modification is of less value in its therapeutical effect than the original method, still there are cases in which the air cannot be forced into the middle ear either during swallowing or phonation, but during a strong inspiration it enters freely. This modification should therefore always be tried where the method fails during the act of swallowing. The entrance of air into the cavum tympani is made much easier during catheterization by a sharp inspiration through the mouth.

Concerning the practical value of these modifications in the position of the palate during the application of my method, simply blowing into the naso-pharynx may be used, especially for children, who cannot be induced to perform the act of swallowing. The entrance of air into the middle ear will,

* Behrend's *Journal für Kinderkrankheiten*, 1864.

† *Centralblatt für die med. Wissenschaft*, 1865.

in that case, be much easier if the child cries during the pressure of air. When the closure of the palate is effected by phonation of a vowel, the air will very frequently not enter the middle ear at all, or only with very slight force. The weak pharyngeal closure is easily forced open by the current of air, and the resistance in the Eustachian tube is only slightly lessened. The same holds good also of the closure by means of the consonants *g*, *k* (*hik*, *huk*), although here the soft palate is pressed more closely against the pharynx wall by means of the base of the tongue. The results are somewhat better when single words are used—the patient pronouncing such words as *König*, *Barique*, etc., during the propulsion of air. The closure of the naso-pharynx lasts longer, and the air is more surely forced into the middle ear than when short syllables are used. In all these modifications the air will enter the middle ear with less force and fails more often than by swallowing, during which a more marked widening of tube takes place than in other movements of muscles of the palate. This may be proved in the simplest manner by the already described experiment of holding a vibrating tuning-fork before the nostrils; its sound will not be increased in any way by phonation of either vowels or consonants, but during an act of swallowing, however, a considerable increase in the sound of the tuning-fork will be perceived in both ears. The dilatation of the Eustachian tube during the application of my method is of the greatest importance from a practical view. In diseases of the ear combined with great resistance in the tube, where currents of air are effective only when they act powerfully upon the walls of the middle ear, the entrance of air is rendered possible chiefly by the material widening of the Eustachian tube during the act of swallowing.

Indeed, it has been shown that even in cases in which air cannot be propelled into the tympanic cavity, when the closure of the palate is effected by phonation of vowels or consonants, a striking improvement in the hearing will immediately follow if the method is applied during the act of swallowing. But even in those cases in which a certain increase in the hearing distance takes place by inflation during the phonation of vowels and consonants, a still more considerable improvement will generally follow the method if applied during an act of swallowing. In general one should use the method with swallowing by preference, and only occasionally the modification with phonation or inspiration. An extensive use of phonation instead of swallowing means the sacrifice of the therapeutical effect for the sake of convenience. Cases in which the air will not enter the middle ear by means of the method with swallowing but still succeeds by phonation are very rare. A similar extraordinary action is also seen with the Valsalvan method, but in spite of that, we are familiar with its inferior therapeutic value.

The most frequent cause for air not entering the middle ear by my method is excessive swelling and narrowing of the isthmus of the tube or stopping with a tenacious plug of mucus. Roosa succeeds in such cases by syringing out the naso-pharynx, after which air will enter by my method. With such hindrances I often found that the method with swallowing was successful nly after a few unsuccessful attempts had been made by inspiration or phonation, or when, as recommended by Gomperz, a long rubber tube was inserted to near the ostium pharyng. tubæ.

On the Therapeutic Value of the Author's Method (Politzerizing) as compared with the Valsalvan Method and Catheterization.

In order to judge of the therapeutic value of the different methods of forcing air into the middle ear it must be understood that in treating middle ear diseases by the air-douche it is not only necessary that air is forced into the cavum tympani, but the benefits, apart from the amount of pressure, depend upon the impulse of the stream of air. Experience shows, in fact, that in middle ear catarrh a strong, quick stream of air forced into the middle ear produces a much more noticeable improvement in hearing than several weak impulses which are gradually increased. The greater the impulse of the entering air, so much more will the membrana tympani and chain of ossicles, which were retracted by the middle ear inflammation, be forced outwards, and the amount and duration of improvement in hearing will be in proportion to the amount the ossicles are approximated to their normal position. For the therapeutic effect of the impulse imparted by the entering current of air speaks the fact that through repeated forcing of air into the middle ear with a strong impulse, generally better results are obtained than through currents lasting for some time with a constant high pressure, as can be produced with the double balloon or air-pump.

As to the effect of Valsalva's method in comparison with mine, experience shows that in cases of catarrh with swelling of the mucous membrane of the tube Valsalva's method is only partially successful or entirely fails. In the same case by my method the air enters the middle ear with full force and greater therapeutic effect. The therapeutic value of Valsalva's method in comparison with mine is therefore very much less.

My method has also the important advantage over the Valsalvan, that the congestion of the vessels of the head which occur during the latter is avoided. There is no question that the venous congestion in the head which occurs during forced expiration is not confined to certain parts of the head, but extends to the ears, as is proved by the frequent injection of the vessels of the membrana tympani during the Valsalvan method. The repetition of such congestion will necessarily create a permanent hyperæmia in the ear by which not only the inflammatory process already existing in the middle ear is increased, but disturbances of nutrition are also caused in the labyrinth. The same is also true of the forcing of liquids by means of the Valsalvan method into the middle ear (Gruber). In my method, however, congestion of the vessels is completely avoided, as no action of the muscles of the thorax is required.

To form a correct opinion as to its value as compared with catheterization, it is necessary to consider, first, that the current of air passing through the catheter cannot exert its full force on the middle ear because the point of the

instrument is not closely grasped by the Eustachian tube, thus allowing a partial reflux of air into the pharynx, and further, that on account of the great friction of the air in the instrument it leaves the point of the catheter with much reduced force. In general as the point of the catheter is directed against the wall of the tube more than in the direction of its lumen, the stream of air is broken and its effect in the cavum tympani is very much weakened.

To some extent these considerations do not apply to my method, for the air forced into the Eustachian tube from the pharynx with a strong impulse will exert an equal pressure in all directions, and will therefore frequently penetrate more surely and with greater power into the tympanic cavity than during catheterization. Indeed, experience shows that in many cases, where only a moderate increase of the hearing distance is observable after the air-douche with the catheter, a noticeable improvement will take place when air is forced into the middle ear by my method.

These facts were confirmed by Barth (*Z. f. O.*, vol. xv.) by experiments with the manometer, which showed that the strongest pressure in the middle ear is produced by my method during swallowing, as the manometer in the external meatus showed a pressure of half the air pressure used, while by phonation and catheterization it was scarcely a quarter of the pressure used.

On the other hand, cases are observed, to be sure, in which the air cannot be forced into the middle ear by my method, while it is perfectly successful by means of the catheter. These cases of middle ear affection, which are specially favourable for catheterization, are such as an excessive loosening of the mucous membrane close a large portion of the tube from the ostium pharyng. to the isthmus. Here the entrance of the beak of the catheter into the tube will separate the adherent walls for a distance, and the remainder will be overcome by the current of air which is directed immediately against it. That the catheterization, in cases of defects in the palate, by paralysis of the palatine muscles and other anomalies of the naso-pharynx which hinder the act of swallowing, is more applicable than my method needs no comparison.

As regards therapeutic value, my method of inflating the tympanic cavity is rarely less effective than the air-douche with the catheter, and is frequently even more so, possessing several advantages over catheterization. These are:

1. The simplicity of its application, which enables the practitioner who is not familiar with catheterization to effect, in many cases, the permeability of the Eustachian tube, and to treat with success a number of affections of the middle ear.

2. The possibility of injecting air into the middle ear in the treatment of many cases in which catheterization of the Eustachian tube is very difficult or impossible. The application of my method of inflation is specially serviceable in the case of children who suffer very frequently from great dulness of hearing in the course of acute or chronic naso-pharyngeal catarrhs, with hypertrophy of the

tonsils, owing to excessive swelling of the mucous membrane of the Eustachian tube and effusion in the tympanic cavity. The method can also be applied in the congenital or acquired deformities and diseases of the naso-pharynx (*vide* p. 90) which prevent the introduction of the catheter. But even when the nasal cavity is normal, this method should be exclusively employed for effecting the permeability of the Eustachian tube in persons who object to the introduction of the catheter, in nervous individuals, in aged people, and in convalescents from severe illness, in whose cases the permeability of the Eustachian tube requires to be established on account of accumulation of secretion in the middle ear, but whose weakness and irritability do not allow the use of the catheter.

3. The application of my method should be used in all those cases in which catheterization of the Eustachian tube can be dispensed with. If it is, therefore, necessary to effect the permeability of the tube by a current of air, this method is always to be preferred to catheterization, because thus the unpleasant sensation caused by the latter proceeding is avoided, the local irritation of the mucous membrane of the tube by immediate contact with the catheter does not take place; and, lastly, because the permeability of both Eustachian tubes can be effected simultaneously. But I must repeat here most emphatically that it frequently happens that catheterization of the tube, as a diagnostic and as a therapeutic agent, cannot be replaced by any other method, especially if the catheter is required as a conducting-tube for the injection of fluids and for the introduction of bougies into the middle ear.

4. My method has also the advantage that, on account of its easy application, it is well adapted for self-treatment, especially in those chronic affections of the middle ear, in which, after the surgical treatment has terminated, inflation of the middle ear is from time to time necessary to retain the improvement effected in the hearing and to prevent a relapse.

For the introduction of vapours into the middle ear by my method, the previously described volatilizer (p. 112) is used, the front piece of which, with a short piece of rubber tube, is introduced into the anterior portion of the nose. For rapidly-evaporating drugs, as sulphuric ether, acetic ether, iodide of ethyl, chloroform, turpentine, iodine, it is quite sufficient to use the pyriform balloon, into which a small quantity of the medicine is introduced, or filling with the vapour from the medicine vial by aspiration. By this method only a small quantity of the vapour reaches the middle ear, and hence the operation must be repeated several times if it is required to inject a considerable quantity into the ear.

In conclusion, I will mention a modification of my method, which has been recommended for injection of fluid into the middle ear and to wash it out. According to the proposal of Saemann,* if the rubber balloon is filled with fluid instead of air, and this is injected into the naso-pharynx with or without swallowing, the nostrils being closed, more or less of the fluid will be forced into the middle ear. The original proposal of Saemann was modified by J. Gruber (1865) in that the injection was made with a syringe instead of with the balloon.

As to the value of these injections as a method of treating chronic middle ear inflammations without perforation of the membrana tympani, experience shows that often only a feeling of fulness, uneasiness, dizziness, numbness in the head, a sensation of warmth or a slight burning in the ear, accompanies it. But occasionally fainting fits occur with the most intense pain in the ear, followed by suppurative inflammation of the middle ear, and perforation of the membrana tympani. This either passes away without further consequences or may go on to chronic suppuration with destruction of the membrana tympani and the ossicles, and to caries of the mastoid process and petrous portion of the temporal bone.

Besides these unfortunate results, in nowise seldom, I have frequently observed cases in which injection into the middle ear for the cure of inflammation has been accompanied or followed by an increase in the deafness and in the subjective noises. A steadily and rapidly progressing aggravation was most strikingly apparent in those cases in which, after the injection of the fluid, pain in the ear was felt, and where considerable engorgement of the vessels of the membrana tympani was observable. It is probable that the pathological changes leading to anchylosis of the ossicula are aggravated by the irritating action of the injection on the lining membrane of the middle ear, and that the union of the ossicula with the walls of the tympanic cavity is only accelerated thereby.

This method of injection leads, especially in affections of one ear only, to very grave consequences, because not infrequently the fluid injected into the naso-pharynx penetrates chiefly into the normal ear on account of the slighter resistance offered to it, and produces a reaction there which is much greater than that produced by the fluid in a diseased ear. I have frequently seen patients, previously affected on one side only, who during treatment after this method were seized with an incurable affection of the middle ear on the other side.

More favourable results are achieved by this method when the membrana tympani is perforated, because the fluid entering into the middle ear can flow off into the external meatus. Its use is only allowable when there is perforation of the membrana tympani of both sides, for in affections of one side only, in spite of the bending of the head to the affected side, the fluid is often forced into the normal ear, causing an acute inflammation there. Saemann's injections, modified by Gruber, possess also the decided disadvantage that their application is unpleasant to most patients, as, even more frequently than with Weber's nasal douche, there occurs pain in the forehead, in the occiput,

* *Die Wasserdouche der Eustachian Ohrtrompete, eine Modification des Politzer'schen Verfahrens*, Deutsche Klinik, 1864.

and not unfrequently also in the upper jaw, lasting several hours, an unpleasant burning sensation in the pituitary membrane, and a tickling and choking in the throat.

In order to inject small quantities of fluid into the middle ear by my method, when the membrana tympani is intact, the following proceeding is recommended: The patient takes a little water in his mouth, and bends the head slightly towards the affected side, when a Pravaz's syringe ½ to 1 full of warm fluid is injected through the nostril, and immediately followed by the current of air from the balloon. By auscultation it can be determined whether the fluid has entered the middle ear. Even by this procedure severe pain in the ear often follows immediately after, for which reason it is well at the beginning to inject only a few drops, and if this is not followed by reaction the quantity of fluid may be gradually increased to ½-1 syringe full.

My method may be used in perforation of the membrana tympani to wash out the cavum tympani with medicated fluids or cleanse it from secretion in the following manner: After the patient has taken a little water in the mouth and bent the head to the opposite side, the external meatus is filled with warm water or warmed medicated solution, and in this position the current of air is forced into the ear. By means of the air passing out through the external meatus often the middle ear is thoroughly washed out and medicaments are able to penetrate into the middle ear more easily.

Methods of Examination and Treatment of the Middle Ear through the External Meatus.

Rarefaction and Condensation of Air in the External Meatus.

The therapeutic effect of the air-douche can in many cases be increased by rarefying the air in the external meatus, as through aspiration of the air the membrana tympani and ossicles are brought nearer to their normal position, and at the same time the increased pressure on the labyrinth is diminished. The condensation of air is seldom used alone for therapeutical purposes, but more often in combination and alternating with rarefaction in the so-called massage of the ossicles (Delstanche), which is used in adhesive processes in the middle ear and in sclerosis of the mucous membrane of the cavum tympani with rigidity of the articulations of the ossicles.

a. Rarefaction of Air in the External Meatus.

Cleland in 1771 recommended the sucking of the air from the external meatus for therapeutic purposes, but it was later forgotten until Moos brought the method of rarefaction of air in the external meatus into use again as a means of treatment. The method formerly recommended, with a syringe provided with an olive tip, works too energetically, as it may produce ecchymoses in the external meatus and on the membrana tympani, or even produce

rupture of the membrane. The method of rarefaction recommended by Lucae with a fungoid-shaped balloon is too inconstant, and requires too much time. To Charles Delstanche we owe the 'rarefacteur' (p. 80), with which repeated rapid aspirations may be made. A frequent adjunct to therapeutic methods is found in the 'masseur' (Fig. 82), lately invented by Ch. Delstanche, which consists of a metal tube 4½ cm. long and 2½ cm. in diameter, enclosing a smaller tube which acts like a valve to a syringe. The recoil of the valve which produces the aspiration is accomplished by a spiral spring between the valve and the bottom of the metal tube. This instrument has proved in many cases of great value in my practice. Lacking one of these instruments, the same object may be obtained by a rubber tube 30 cm. long, connecting an olive tip to fit hermetically into the external meatus, with a strong balloon, 6-7 cm. in size, or with the ordinary large rubber balloon. The aspiration is accomplished in this manner: The balloon is compressed and the olive tip inserted into the external meatus, when the balloon is allowed to slowly expand. This procedure may be repeated 4-5 times at one sitting.

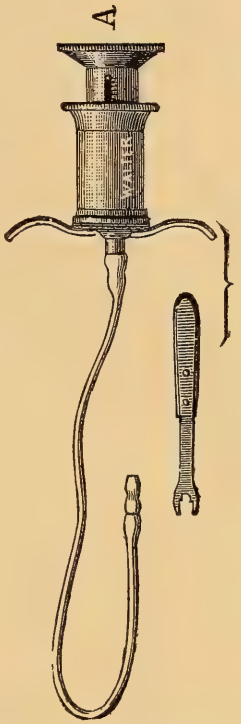

Fig. 82.—Masseur of Chas. Delstanche.

Rarefaction of air in the external meatus is indicated: 1. In all catarrhs of the cavum tympani and Eustachian tube in which the membrana tympani is retracted.

2. In adhesions between the membrana tympani and inner wall of the cavum tympani.

3. After paracentesis of the membrana tympani to aspirate serous or mucous exudate out of the cavum tympani into the external meatus.

4. To aspirate pus from the cavum tympani into the external meatus (E. Politzer) in cases where the injection of air by the tube is impossible, or does not succeed, and farther, in localized suppuration of the cavum tympani which do not communicate with the tube.

5. In subjective noises in the ear, which often cease or are much diminished and become less troublesome after its use (Hedinger). Besides these, it often produces a noticeable subjective easing in the head and ear in middle ear catarrh which gives this treatment a special value in treating these diseases.

6. To relieve giddiness and attacks of dizziness following increased

labyrinthine pressure. This may be produced either by the product of disease in the middle ear or through a pathological process in the labyrinth itself. Attacks of dizziness, which are brought about by syringing the ear when there is perforation of the membrana tympani, or through other manipulations of the ear, may be quickly relieved by rarefying the air in the external meatus. Delstanche succeeded in a case of epilepsy in stopping the epileptic attacks by treating the disease of the ear with the 'rarefacteur.'

b. Condensation of Air in the External Meatus.

Condensation of air in the external meatus is used much less in treatment of middle ear disease without perforation of the membrana tympani than rarefying the air. On the other hand, in a class of cases with perforation of the membrana tympani, condensation of the air in the external meatus gives good results. In this method, recommended by Lucae, the condensation of the air is accomplished in the best manner with the 'masseur' of Delstanche or with the balloon apparatus previously described. Through compression of the air in the meatus it will be forced through the tube into the pharynx, thereby the air will leave the ostium pharyng. tubæ with a plainly audible rattling noise, or, when there is very little fluid secretion, with a dry snapping sound.

Condensation of air in the external meatus is used:

1. For diagnostic purposes, and especially to decide as to a perforation of the membrana tympani in cases where the opening is not visible and the injection of air through the tube gives a negative result. If the end of the auscultation tube is placed in the nostril of the patient, while the patient breathes quietly through the mouth, by every condensation of air in the external meatus the noise of the air escaping into the pharynx will be plainly heard. When there is still secretion in the middle ear there will be a crepitating sound, but in a dry perforation only a dry, crackling noise (method of the author).

2. For therapeutic purposes:

(*a*) In perforation of the membrana tympani to remove the secretion from the middle ear in cases where neither the air-douche by the tube nor rarefying of the air in the external meatus succeeds in removing it. By this means the secretion will be forced from the anterior portion of the cavum tympani and tube into the pharynx.

(*b*) After paracentesis of the membrana tympani, where tenacious masses of mucus which are hard to remove must be forced through the tube into the pharynx.

(*c*) In dry perforations, to open up the Eustachian tube when it cannot be accomplished from the ostium pharyngeum.

(*d*) To wash out the cavum tympani from the external meatus, if this is not possible through the tube or by my method. This procedure is very simple. After the cleansing of the middle ear from secretion by means of the air-douche and syringing, the external meatus is filled with warm water, then the olive tip of the tube is hermetically inserted, and by means of compression of the air-balloon the water is forced through the tube into the pharynx. To syringe a larger amount of water through, a large syringe can be used which is provided with an olive tip. This procedure has been very serviceable to me in several tedious cases of middle ear suppuration where other methods failed.

(*e*) By adhesions between the membrana tympani and the inner wall of the cavum tympani, used alternately with rarefaction of air in the external meatus in order to increase the working of the latter.

(*f*) Where there are subjective noises, which are neither diminished by the air-douche through the tube, nor by rarefying the air in the external meatus, there is sometimes observed (although very seldom) a decrease of the noises after the condensation of air in the external meatus.

The condensation of air in the external meatus, as well as washing the middle ear by this means, is contra-indicated in such obstructions of the Eustachian tube that the air will not pass by the tube with a strong compression of the balloon. In these cases the pressure exerted upon the fenestræ of the labyrinth very often produces great dizziness, ringing in the ears, and deafness, to relieve which the air should be immediately aspirated from the external meatus.

(*g*) Rarefying and condensing the air in the external meatus. The use of both methods following quickly after each other, called by Delstanche ' massage of the articulation of the ossicles,' produces an increased movement of the chain of ossicles, whose movements are diminished either by rigidity of the articulation, or through adhesion. This method is specially adapted for imperceptible adhesions in the cavum tympani and in the simple sclerosis of the mucous membrane of the middle ear.

C. Tests for Hearing.

The tests for hearing are of the greatest importance in the diagnosis of the diseases of the ear; for they serve not only to determine the extent of the disturbance of hearing, but not unfrequently also to localize the affection, inasmuch as in cases in which the other objective methods of examination give a negative

result, we are enabled to judge whether the anatomical cause of the functional disturbance has its seat in the apparatus for the conduction of sound or in the nerve apparatus. But they are also of special value because by means of them, while the patient is under observation, we can note the course of the disease, and also the result of treatment.

As our ear perceives not only the waves of sound, transferred immediately from the air to the sound-conducting apparatus, but also the vibrations transmitted through the cranial bones, the power of perceiving waves transmitted in both ways must be tested separately for diagnostic purposes.

A. *Testing the Acuteness of the Perception of Sound-waves transmitted through the Air to the Membrana Tympani.*

1. *Testing the Sharpness of Hearing for Simple Tones.*

(*a*) *Testing for the Acuteness of Perception for the Watch and Acoumeter.*—The expedients hitherto in use for testing the function of hearing, the watch, the tuning-fork, and speech, have proved deficient for the exact testing of the acuteness of perception of the organ of hearing.

To test the acuteness of hearing for simple tones the watch* has until very recently been used for the production of sound. As, however, different watches vary considerably as to the pitch and intensity of their sound, it is clear that the results of testing with different watches must also be different, and that they are therefore not suitable for a precise indication of the acuteness of hearing.

These imperfections have lately induced me to attempt the construction of a new acoumeter, giving a definite volume of sound, intended as a substitute for the watch as a test of hearing.

This acoumeter (Fig. 83, actual size) consists of a horizontal steel cylinder (*c*), 28 mm. long and 4·5 mm. thick, connected by means of a tightly-fitting screw with the perpendicular vulcanite column (*h*, *f*). Above the place of attachment of the cylinder the percussion-hammer (*k*, *e*), which can be turned round its axis, is fastened in an oval orifice of the vulcanite column, and produces the tone by falling upon the steel cylinder.

As the intensity of the sound depends on the height from which the percussion-hammer falls, to produce in all instruments an equal height, a small piece of vulcanite (*d*) furnished with a soft india-rubber plate is fixed at the posterior periphery of the column as a check, upon which the posterior short lever of the hammer is pressed. Hedinger has the hammer moved by clock-

* As Oscar Wolf quite correctly remarks, the ticking of a watch is not a noise, but a sound having a distinct pitch.

work; Burckhardt-Merian, after the method of Neff's hammer, has it raised by an electric current. At the superior and inferior extremities of the column are two flat semicircles (*b*, *a*), by which two fingers may grasp the instrument, the superior semicircle for the forefinger and the inferior for the thumb. Below the superior semicircle, parallel with the axis of the percussion-hammer, there is a ring on the vulcanite column, into which a pin, having a round metal plate attached (*i*), can be inserted. This last contrivance is for testing the perception of the cranial bones by bringing the metal plate into contact with the temple or with the mastoid process while the meatuses are closed. In the same manner, in cases where the tone of the acoumeter is not heard even on the closest proximity, the round metal

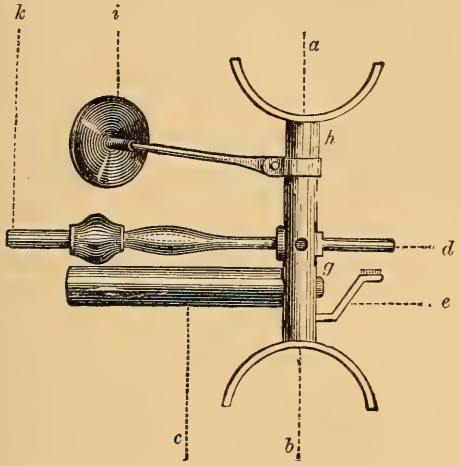

FIG. 83.—THE UNIVERSAL ACOUMETER DESIGNED BY THE AUTHOR.

plate is brought into contact with the orifice of the external meatus, to find whether the tone of the acoumeter is perceived by contact.

The cylinder is tuned to c and gives the sound of a loudly-ticking watch. An exact tuning of the cylinder is produced by boring out, and its tone is indicated by blowing into the mouth of the cylinder. It is evident that the instrument, as a universal acoumeter, will only fulfil its object if all the parts in every instrument are exactly alike and each instrument exactly tuned. In more severe deafness, where the acoumeter is not heard, I often use the metronome.

While testing the hearing with the acoumeter, just as with the watch, the direction of the instrument to the external orifice of the ear must be considered, as the acuteness of hearing is materially modified by the position of the origin of sound to the ear. As a rule, the tone will be heard more intensely and also at a greater distance if the line connecting the external orifice of the ear and the

acoumeter is not perpendicular to the lateral portion of the head, but is directed more forwards. In case of repeated testing the acoumeter should therefore always be moved and fixed in that direction.

To estimate the acuteness of hearing exactly, a centimeter-measure is used, which is held horizontally and touches the head immediately below the lobe of the ear; but care must be taken to avoid contact of the acoumeter with the measure, on account of the immediate conduction of the vibrations to the cranial bones. In every consulting-room, moreover, either on the floor or on the wall, a meter-scale should be marked off so as to be able to estimate exactly the acuteness of hearing for greater distances as well.

Each ear must be separately tested in regard to the acuteness of hearing; for which purpose, during the examination of one ear the meatus of the other is closed with the moistened finger. The hearing-distance is measured by gradually bringing the instrument nearer to the ear in the direction of the measure, until the patient is able to give the exact number of strokes of the acoumeter. To check the statements as to the perception of the tone the patient is requested to cover the eye with the hand of the same side, so that he cannot see the place from which the sound proceeds.

It must be stated here, in order to properly judge of the value of testing the hearing, that the acuteness of hearing undergoes great variations in the same person, not only on different days, but also at different times of the day. It varies also from the influence of the temperature and humidity of the air, as well as from somatic and psychical conditions. It will be noticed from the testing that the acuteness of perception of the auditory nerve shows great variations within short spaces of time. That the sounds occurring during the day influence the result very much is self-evident.

When testing the acuteness of hearing with the acoumeter or with the watch, differences in the distance will be frequently observed according as the instrument is brought nearer to the ear from without the boundary of perception, or is farther removed from the ear after the first perception of the tone. In the latter case the hearing-distance is almost always greater than in the former. The cause of this, in my opinion, is that by approaching the ear with the instrument not heard as yet, the extremities of the auditory nerve, which are at rest, require a greater amount of sound to disturb their equilibrium, and that therefore the origin of sound must be brought nearer to the ear to irritate the auditory nerve; while by withdrawing the origin of an already perceptible sound from the ear the auditory nerve, being in a state of irritation, is still kept irritated by vibrations of lesser intensity, and the sound is perceived at a greater distance.

The average distance at which the acoumeter may be heard by a large

number of normal ears in a noiseless room, as tested by Hartmann, Chimani, and the author, was 15 m. According to the proposition of Knapp and Prout the relative proportion of the normal hearing power when it is heard at 1 m. is $\frac{1}{15}$, when heard at 10 cm. it is $\frac{0}{1}\frac{1}{5}$, at 3 cm. it is $\frac{0}{1}\frac{0}{5}\frac{3}{}$. According to the experience of Bezold and myself the distance at which the tone of the acoumeter can be heard remains more in proportion to that of speech than the distance for the watch. However, we frequently see cases where a great disproportion exists between the two distances. In so far as there is no direct relation between the hearing distance for the acoumeter or watch and speech, but often a great disproportion, the testing with the acoumeter or the watch has only a relative value. An advantage of this method of testing is in cases with such a slight amount of disturbance of hearing that it can scarcely be detected even by whispering, but is discovered by testing with weaker sounds. Although there are frequent exceptions, yet in many cases a judgment as to the general improvement may be made by the increase of the hearing distance for the acoumeter or watch.

The acoumeter of Hartmann, Dalby, Cazzolino, Gradenigo, and Urbanschitch, made after the principle of the sonometer of Hughes, in which the striking of a Neef's hammer is conveyed to the ear by a telephone, and by means of changing the induction coil gradually made weaker or stronger, I have not tested in practice, as the strength of the stroke varies with the filling of the element. Besides this it possesses, as all acoumeters do, the fault that we cannot judge, from the increase of the hearing distance for the tone of the acoumeter, as to the increase of the hearing distance for speech.

(*b*) *Testing of the Perception of Different High Notes Conducted through the Air.*—The equipment of the specialist for this purpose consists of the following: a series of tuning-forks, different high-toned whistles, a series of König's steel cylinders, and different musical instruments.

Tuning-forks.—In the testing of the hearing for diagnostic purposes, the examination with the tuning-fork has a prominent place, especially since such progress has been made during the last few years in the combined examination with high and low-toned tuning-forks for bone and air conduction, in the differential diagnosis between middle ear and labyrinth affections.

The contradictory statements which result from the testing of hearing by different authors undoubtedly occur from the want of unity in the methods employed and the varying styles of tuning-forks used. A unanimity of method in the testing of hearing, as well as the use of the same form of tuning-forks and instruments, appears therefore very desirable, and should be done to avoid irregularities in the results.

While some otologists consider a complete octave series from $C^{-1}=64$ vibrations to $c^7=16{,}384$ vibrations, in all 9 tuning-forks, as sufficient for diagnostic purposes, Moos uses tuning-forks through 8 octaves, A^1-g^8,

and Bezold eight with movable clamps: contra C with 32 vibrations contra A, the E, A, e, h, g^1, and sharp,* and besides these a deep organ pipe with $687\frac{1}{2}$, a higher with 1,760, and lastly, a Galton whistle, which will be described later. With this apparatus (by moving the clamps on the tuning-forks) every tone from contra C to the highest perceivable tone on Galton's whistle, about 9-10 octaves, may be given. This apparatus is specially suitable for finding breaks in the scale of perception. Each ear must be tested separately for the upper 5 octaves, but for the lower 3 octaves it is unnecessary to stop the other ear.

For the diagnostic purposes of the practising physician, to test the perception for the upper, middle, and lower tones, three tuning-forks at least are necessary—$C = 128$, $c^2 = 512$, $c^4 = 2{,}048$.

In most tuning-forks upon striking, especially upon a hard substance, besides the fundamental tone there are a number of ringing over-tones which tend to destroy the effect of the examination. To remedy this I proposed the use of clamps on the prongs of the tuning-fork which can be moved when wished and fastened by a screw. Later I have used tuning-forks without the clamps, having the prongs filed down near the place where they bend thinner than at their extremity. In these tuning-forks, when struck on some soft substance, there are no over-tones perceptible. In the small Blake's tuning-forks, to produce a clear ground tone, the ends of the prongs must be very much thickened. Lucae uses a small English tuning-fork provided with a scale on which by moving the clamp an increase of the tone can be made up to one octave.

In testing the perception for the tuning-fork through the air, the decrease of the hearing distance of the diseased ear is determined as compared with the normal hearing distance. The method of testing the acuteness of hearing according to the time it is heard was brought forward by Conta.† The best tuning-fork for this purpose is c^2 (512 v.), which is made to vibrate by moderately striking one of the prongs on the palm of the hand, or a piece of wood covered with leather and held before the ear of the patient until he says he can hear it no longer. As quickly as possible it is then brought near our own ear (or if a one-sided affection before the

* As in most text-books the number of vibrations for the different tones is not correctly given, I will add here a table from Appun, in which the number of vibrations for the pure tones is given.

$C_{-2} = 32$	$D_{-2} = 36$	$E_{-2} = 40$	$F_{-2} = 42{,}_{66}$	$G_{-2} = 48$	$A_{-2} = 53{,}_{33}$	$H_{-2} = 60$
$C_{-1} = 64$	$D_{-1} = 72$	$E_{-1} = 80$	$F_{-1} = 85{,}_{33}$	$G_{-1} = 96$	$A_{-1} = 106{,}_{66}$	$H_{-1} = 120$
$c = 128$	$d = 144$	$e = 160$	$f = 170{,}_{66}$	$g = 192$	$a = 213{,}_{33}$	$h = 240$
$c^1 = 256$	$d^1 = 288$	$e^1 = 320$	$f^1 = 341{,}_{32}$	$g^1 = 384$	$a^1 = 420{,}_{66}$	$h^1 = 480$
$c^2 = 512$	$d^2 = 576$	$e^2 = 640$	$f^2 = 682{,}_{64}$	$g^2 = 768$	$a^2 = 853{,}_{32}$	$h^2 = 960$
$c^3 = 1024$	$d^3 = 1152$	$e^3 = 1280$	$f^3 = 1365{,}_{28}$	$g^3 = 1536$	$a^3 = 1706{,}_{64}$	$h^3 = 1920$
$c^4 = 2048$	$d^4 = 2304$	$e^4 = 2560$	$f^4 = 2710{,}_{56}$	$g^4 = 3072$	$a^4 = 3413{,}_{28}$	$h^4 = 3840$
$c^5 = 4096$	$d^5 = 4608$	$e^5 = 5120$	$f^5 = 5421{,}_{12}$	$g^5 = 6144$	$a^5 = 6826{,}_{56}$	$h^5 = 7680$
$c^6 = 8192$	$d^6 = 9216$	$e^6 = 10240$	$f^6 = 10842{,}_{24}$	$g^6 = 12288$	$a^6 = 13653{,}_{12}$	$h^6 = 15360$
$c^7 = 13384$	$d^7 = 18432$	$e^7 = 20480$	$f^7 = 21684{,}_{48}$	$g^7 = 24576$	$a^7 = 27306{,}_{24}$	$h^7 = 30720$

† Arch. Ohrenh. Bd. i. S. 107.

other ear of the patient), and the difference of time noticed between the perception of the diseased and the normal ear. This method can give no pretension to precision, for in repeated testings the difference in time of perception between the diseased and normal ears shows great variations, and farther, it is not in proportion with the disturbance in hearing. Nevertheless, we can use it with the other methods of examination to verify an increase of hearing during the treatment, that is, to determine an increase or decrease of hearing by later examinations.

In an affection of both sides, to prove the difference in the perception between both ears, the vibrating tuning-fork (c^2) is changed from one ear to the other at short intervals, being held as nearly as possible at the same distance on each side. Generally the tuning-fork will be heard the faintest by the ear which has the greater deafness; the opposite is seldom the case. In slight disturbances of hearing the difference in the perception of the two ears must be tested by vibrations which are as weak as possible, and the difference in time also noted. By this method of testing it is very often noticed, especially in affection of one side with increased tension in the sound-conducting apparatus, that the tuning-fork is perceived $\frac{1}{4}$, $\frac{1}{2}$, sometimes even a whole tone higher by the diseased ear, but seldom lower than the other ear.

The testing of the perception of low and high tones conducted through the air has recently received a new importance, which it rightly deserves, for the differential diagnosis of middle ear and labyrinth affections. By a large amount of investigation, the result of which I published in the *Archives für Ohrenheilkund*, vol. vi., 1871, I proved by experimental examination on the cadaver that in obstacles to the conduction of sound in the middle ear, generally high tones are better heard than low ones. For this reason, testing with high and low tones appeared to be suggested. Lucae first called attention to the diagnostic value of testing with low-toned tuning-forks. He found that in middle ear affections, where the hearing power for speech was very much decreased, low-toned tuning-forks are only very faintly heard, or not at all; that, on the other hand, in labyrinth affections, even where the hearing power is very much decreased, the lower tones of the tuning-fork are very well heard.

From these facts Bezold formed the conclusion that the sound-conducting apparatus participates only in conducting the waves of sound in the lower portion of the scale, and that for the upper portion of the scale it is superfluous. The perception will be the more decreased by affections of the sound-conducting apparatus the

lower we go in the scale. The failure of the lower tones is therefore very important for the diagnosis of middle ear affections, especially when other symptoms fail.

Although clinical observation also gives that, in general, in middle ear affections, high tones are better heard than lower ones, still, on account of the frequent exceptions, it is only to be depended upon in connection with the general result of the examination of the patient. Positive results are only given of the presence of hindrances to sound conduction, as with these it is very exceptional that low-toned tuning-forks are heard far down in the scale. Less dependence can be placed upon the testing with high tones, as in middle ear affections with greatly diminished hearing, the perception for the upper tones of the scale may also be lacking (Burckhardt-Merian, Rohrer). On the other hand, in marked cases of disease of the auditory nerve, the perception for the lower tones may be entirely wanting, while, according to my own observation, very often high tones, up to nearly the limit of the capability of perception, are distinctly heard.

For the testing of the perception of the lower tones, c = 128, is sufficient for the examination of most cases, but in some cases $C^{-1} = 64$ and $C^{-2} = 32$ should be used for examination. For the testing of the perception of the higher tones the tuning-forks should be used, c^4 or c^5 (2,048 and 4,096), and for the testing of the upper part of the scale Galton's whistle (brought into use by Burckhardt-Merian in 1878) is used.

Galton's whistle consists of a small, covered, cylindrical whistle which is lengthened and shortened by a valve moved with a micrometer screw. The lower portion of the valve is in connection with a hollow cylinder which extends over the cylinder of the whistle. On the side of the whistle is a scale to show the tens, and around the hollow cylinder a scale to show the single numbers. The blowing on the whistle is done by a small rubber balloon connected with it. According to Burckhardt-Merian the Galton whistle has a compass of more than the three uppermost octaves with 6,481-84,000 vibrations to the second. This instrument is specially suited for testing the capability of perception for the high tones. Above the limit to which the perception of our auditory nerves responds for the highest notes, vibrations are proved by the response of a sensitive gas flame.

Besides the Galton whistle, Blake, Burckhardt-Merian, and Rohrer recommend for testing the upper limit of the perception of hearing, a series of König's cylinders of 20,000 to 100,000 vibrations in the second with intervals of 5,000 vibrations. The diameter of the sounding tubes is about 20 mm., and their lengths vary according to the different tones of the series. Appun's apparatus for testing the upper tone limit consists of 11 tuning-forks of 2,000-50,000 vibrations (Kessel). The forks are set in vibration with a violin bow.

Testing with high-pitched tuning-forks and with Galton's whistle will only give a good result when the difficulty of hearing affects both sides and has pro-

gressed to a considerable extent. In unilateral ear affections, or where both are affected but one only to a slight degree, the results of testing are not reliable, as in spite of carefully hermetically closing the normal or less affected ear, the perception of the high tones cannot be excluded from the closed ear. In certain cases the perception of the examined ear is tested by localizing the tone and conducting it to the ear with a long speaking tube.

The perception for high tones, especially those of Galton's whistle, decreases in old age. Between 60 and 70 years of age g^3 will not be heard constantly (Moos).

For testing the perception of lower and higher tones, as well as proving the presence of gaps in the scale of tone perception, a musical instrument may be used, a piano or harmonium being the best.

(*c*) *The Author's Test to prove the Perception of the Vibration of the Tuning-fork through the Eustachian Tube.*—The experiment, which I first brought forward (p. 65), of holding a vibrating tuning-fork ($c^2 = 512$ v.) before the nostrils during an act of swallowing, when it will be more loudly heard in both ears, is suitable for a series of cases: (1) to prove the permeability of the Eustachian canal; (2) to diagnose an obstruction to the conduction of sound in the middle ear. The results of this experiment are:

1. In middle ear affections of one side with impermeability of the Eustachian tube, resulting from swelling of its mucous membrane covering, through clogging with secretion or a true stricture, the tuning-fork c^2, when held before the nostrils, will in most cases be heard only in the normal ear. If with difficulty of hearing limited to one side, a diagnosis of middle ear disease is made by examining the membrana tympani, or through Weber's or Rinne's test, and the tuning-fork before the nostrils is heard louder in the normal ear, an impermeability of the Eustachian tube on the diseased side is very probable.

When in such cases the tube is made permeable by means of the catheter, or my method, and the tuning-fork is held before the nostrils, it will be heard louder in the diseased ear. This may be either transient or remain. This symptom is a favourable prognostic sign, in so far that the restoration of the permeability of the Eustachian tube, which was formerly closed, may be reassured.

2. In those unilateral middle ear affections, where the Eustachian tube is not obstructed, a c^2 tuning-fork held before the nostrils will often be heard louder in the diseased ear (as in Weber's test). Exceptions are not rare. When, therefore, in unilateral difficulty of hearing, and by ocular inspection, or through Weber's or Rinne's test, a hindrance to sound conduction is demonstrated, if the tuning-fork (c^2) is heard louder than in the normal ear it is certain that

the Eustachian tube of this side is permeable. This symptom occurs most often in unilateral, chronic, so-called dry middle ear catarrh, and quite often in those middle ear processes due to prevalent inflammation, especially with a dry perforation and small amount of swelling of the mucous membrane of the middle ear.

In ear affections of both sides, where one ear is more affected than the other, this test seldom gives the previously described result.

3. After middle ear suppuration with persistent perforation of the membrana tympani, with the formation of cicatrices on the membrana tympani, and with thin cicatrices which are stretched before the ostium tympani tubæ, occasionally during swallowing the sound of the tuning-fork may be heard by the examiner as much increased through an auscultation tube placed in the ear of the patient.

4. In unilateral labyrinth affections, where the objective examination and all the symptoms leave no doubt of the presence of affection of the auditory nerve, the c^2 tuning-fork will be heard only in the normal ear, as well during swallowing as when the tube is in a state of rest.

2. *Testing the Hearing-power for Speech.*

Oscar Wolf * did the great service, by means of a large number of thorough investigations, of establishing the key-note of the different sounds of speech, as well as the distance at which they could be distinguished. The results which he gave serve as a foundation for the testing of hearing by means of speech.

According to Wolf, speech has a compass of five octaves, from c to c^5. The deepest tone is that of R lingual, the highest is S. The greatest strength of tone and the most timbre belongs, according to Wolf, to the vowel A, which can be heard at 252 m., and the smallest to the H sound, heard at 8·4 m. distance. He calls the following self-toned: R sound lingual, B, K, T, F, S, Sch, and G soft in contradistinction to L, M, N, and W, which borrow their sound from the adjoining vowels.

Fixing the hearing-distance for speech with a view of estimating the amount of disturbance of hearing is more difficult than testing the hearing-distance for a constant sound. During a careful observation of this method of testing, it strikes us at once that the vowels are generally perceived more surely and at a greater distance than the consonants. For this reason patients frequently hear only the vowels of a word of several syllables, and when repeating what they have heard pronounce another word which contains the

* *Sprache und Ohr : Acustisch-physiologische und pathologische Studien* (Braunschweig, 1871), and *Neue Untersuchungen über Hörprüfung und Hörstörungen ; A. f. Augen- und Ohrenheilk.*, vol. iii.

same vowels but different consonants (for instance 'Vater' instead of 'Wasser;' 'Gabel' instead of 'Tafel'). It is also observed that those words in which vowels of a clear sound, A, E, and I, occur are more easily perceived than those which contain the more or less dull vowels O and U. For this reason it comes that the self-toned consonants are heard with more difficulty than those which borrow their sound.

The recognition of separate words at a certain distance depends also on the arrangement of the vowels and consonants, as also on the rhythm and cadence of the syllables, so that many words are heard and understood at a disproportionately greater distance than others.

Other facts which preclude the exactness of testing the hearing for speech are the differences in volume and timbre of the voice, as well for ordinary conversation as whispered speech in different individuals, and the impossibility, even with the most careful practice, of governing the speech so as to have the same strength of voice on different days.* The results of the testing of the hearing for speech cannot therefore be absolute, but only have a relative value.

In spite of the various imperfections thus seen to be associated with the testing of hearing by speech, we yet look upon it as an indispensable test in the estimation of the disturbance of function and of the results of treatment. Observations show, however, that there often exists a striking disproportion between the hearing-distance for simple tones and for speech, and that not unfrequently during the treatment of aural patients the hearing-distance for simple tones increases to a considerable extent, while the distance for the understanding of speech has only slightly increased, and *vice versâ*. This shows that results obtained by testing the hearing with the watch, or other origin of sound, do not indicate the degree of the functional disturbance for speech. But as our endeavour in the treatment of functional disturbances is mainly centred in the re-establishment or improvement of the power of hearing speech, the application of speech as a means of testing cannot under any circumstances be dispensed with.

To ascertain the hearing-distance for speech (quantitative test, according to O. Wolf), the ordinary conversation is used as well as whispering. By the latter the result of the test is so much more sure as the ordinary volume is diminished by the speaking, and the ear receives sound-waves differing from each other much less in volume than those of loud speech (O. Wolf).

Inasmuch as the testing by whispering gives much less difference in the distance for single words than in loud speech, where the space is large enough to allow it, one should test the hearing-distance for both whispering and conversation. No positive relation exists between them, and the perception for whispering gives no exact statement as to the perception for conversation. The ascer-

* The proposition of Lichtwitz, to use Edison's phonograph in testing for speech (Congrés internat. Otolog. et Laryngol., 1889), has not, up to the present, found a place in practice.

taining of the hearing-distance for the latter appears very important, as the conversational tone alone gives a measure of the hearing in practical life. In severe grades of disturbance of hearing, the conversational tone can alone be used for testing.

According to Hartmann and Siebenmann, the average normal hearing-distance for whispered speech in a room as noiseless as possible amounts to 25-26 meters, during the ordinary noise of the day to about 20 meters, a distance which agrees with that (60 Frankfort feet) stated by Wolf (*l. c.*). R. Chimani found it in a quiet hall of the Vienna Garrison Hospital to be a distance of 21 meters. Bezold, with his weak, slightly accentuated whispering, found the distance by children only 17-20 m.

Besides the quantitative testing of hearing, it is necessary, according to O. Wolf, for a differential diagnosis to use the qualitative test for speech. He proceeds accordingly to establish the hearing distance by comparing the perception for high, medium, and lower tones of speech, as compared with the normal perception. According to the method proposed by Wolf,* one tests the patient first by means of the self-sounding consonants alone, R lingual, B, K, T, F, S, Sch, and G soft, as well as the very deeply whispered U; besides this, words of speech are used in which the testing sound is very prominent. The sound-borrowing letters, L, M, N, and W, may be disregarded while testing. The S-sound with the greatest number of vibrations will be heard very badly, or not at all when there are hindrances to sound-conduction, the Sch-sound will be heard a little better. Failure to hear the F-sound occurs in labyrinth disease, according to Wolf. The deepest tone of speech, according to the same author, is the lingual R (with 16 double vibrations); the perception for it is often lacking in defects of the membrana tympani. The failure of perception for the lingual R and the whisper U, when the conduction apparatus is intact, with other symptoms, may be considered as an important point for the diagnosis of a labyrinth affection.

The list of words proposed by O. Wolf and Schwabach as suitable for testing are divided into three groups:

Group I. (*a*) High pitched and far-reaching hissing sounds, S, Sch, and G soft:

Strength of tone for the normal ear, Sch-sound . 200 paces.
,, ,, ,, S-sound . 175 ,,
,, ,, ,, G or Ch soft . 130 ,,

Test words: Messer, Strasse (spoken like Schtrasse), Säge, Kessel, Strauch, Schläge.

* Compare also Schwabach, *Archiv f. Ohrenheilkunde*, vol. xxxi., p. 82.

(*b*) High, weak F-sounds, F and V.

Strength of tone of F-sound . . . . . 67 paces.

Test words: Feder, Frankfurt, Ferdinand, Friedrich, Fuss.

Group II. Explosive sounds of medium pitch, B (pitch e^2), K (pitch d^3), T (pitch d^3 sharp):

Strength of tone: K- and F-sound . . . . . 63 paces.

,, ,, B-tone . . . . . 41 ,,

Test words: Teppich, Tante, Kette, Kappe, Teller, Tinte, Bitte, Kuppe.

Group III. Deep tones: U (pitch f^0), R lingual without voice-sound (pitch of the prevailing tones, $C^{-3}=16$ double vibrations in the second).

Strength of tone: U (whispered) . . . . . 50 paces.

,, ,, R (spoken at end of tongue) . 41 ,,

The U is only suitable, as well as the other vowels, to be used in whispered speech for differential diagnosis.

Test words: Ruhe, Bruder, Ruhrort, Reiter, Ruhm, Rauch, Reise.

When certain words are repeatedly used for testing, they will be easily guessed by the patient, so that errors may arise in judgment as to the improvement. To guard against this, other irrelevant words should be inserted among them. The testing with whole sentences is not advisable, as the hearing of certain words will lead the patient by combination to guess the sense of the whole. The testing with numbers is very imperfect, as by repeated tests the whole number is guessed from hearing the vowel.

For the judgment of improvement in the hearing of speech during the treatment, it is necessary that there be a great difference in distance. As, however, many words are heard at widely different distances than others, it is better at the first examination to fix the distance at which a certain number of words can be heard, and to make a note of them, and to compare the hearing-distances in future examination for the same words. With children easily comprehended words should be used, and limited to four to five in number, as children easily become tired and restless, and do not listen to the words pronounced to them.

When testing the acuteness of hearing for speech, special care must be taken that the spoken words are not read by the movement of the mouth, as many patients, especially those who have been hard of hearing since childhood, possess a particular skill in reading the lips.

Each of the ears must be separately tested, the one being turned directly towards the speaker, while the other is closed as completely as possible with the moistened finger-tip. In cases of one-sided deafness, special care must be taken to close the normal ear as nearly hermetically as possible, because words spoken moderately loud in

the neighbourhood of the diseased ear may be easily heard by the normal one if insufficiently closed, and in this manner mistakes may take place. In such cases, speaking loudly in the neighbourhood of the patient must therefore be avoided, and it is advisable, in cases in which it is desirable to ascertain that the patient has really heard the speech with the diseased and not with the normal ear, to test the hearing with both meatuses closed. If after the diseased ear has also been closed, speech is still heard at the same distance as before, it may be assumed with certainty that the sound enters into the normal ear; if speech is not heard, there can be no doubt that it had been heard by the diseased ear before it was closed.

In cases of severe deafness, to determine whether speech is heard by means of the membrana tympani and ossicles or through the cranial bones and Eustachian tube, a speaking tube should be used with the funnel held outside of the patient's hearing distance. If speech is not heard through the tube, then sound-conduction by means of the ossicles does not exist. To demonstrate if it is heard by means of the Eustachian tube, in repeated examinations within the hearing-distance the mouth and nostrils should occasionally be firmly closed. It is certain that the patient hears by means of the tube if words which are clearly heard at a certain distance after closing the mouth and nostrils can no longer be perceived.

Besides the separate examination of each ear it is advisable to find the combined hearing distance for both ears for speech, as this is not in relation to the results of the separate examination in most cases, and further, this hearing distance is of most importance in practical life. The testing is performed as follows: the patient stands opposite to the physician, facing him directly and with his eyes directed downward to the floor. I hold this method of testing the hearing-distance for speech, before and after treatment, as the more important, as it gives the surest judgment of the amount of improvement in hearing.

I will here note a few observations as to the disturbances of hearing for speech which will be met with. Most patients, when their deafness is not too great, understand speech which is not too loud but clearly accentuated, better than too loud, quickly spoken words. Female voices with clear, high timbre are better understood than flat, low-toned male voices. Habit plays a very important part; the speech of relations and acquaintances is much easier heard than that of strangers. Words which are used in daily life are heard at a greater distance than unfamiliar ones; a foreign idiom is heard with much more difficulty than the local speech. In cases with otherwise not very marked disturbance of hearing, the deafness of many patients for certain special words is remarkable. Exceptionally, with slight deafness, speech is sometimes heard better at some distance than close at hand. In some very rare cases whispering is heard at a greater distance than loud speech

(Burckhardt-Merian). Musical tones are better perceived than speech (p. 62). For this reason people with even a high degree of deafness can enjoy a concert, while they are totally unable to hear the spoken drama.

B. *Testing the Perception of the Waves of Sound conducted to the Ear through the Cranial Bones.*

1. *Testing with the Watch and the Acoumeter.*

If a vibrating body is brought into contact with the cranial bones, the vibrations will be communicated to all parts of them, and therefore also to the ear. These vibrations reach the labyrinth in two different ways, viz. (1), by immediate conduction from the solid parts to the labyrinth, and (2) by transmission from the cranial bones to the membrana tympani and the ossicula, to be conducted by them to the labyrinth (Cranio-tympani Conduction. E. H. Weber, Lucae).

The perception of the waves of sound, conducted from the solid parts of the head to the ear, is modified in many ways by morbid changes in the organ of hearing. Clinical experience sufficiently confirms this, and attempts have often been made to utilize these changes for diagnostic purposes. These changes in bone conduction for the watch do not give the important differential diagnostic symptoms which were imputed to them by the older ear specialists. Nevertheless, testing the conduction through the cranial bones must not be omitted, for if not in all, at least in a great number of cases, important indications as to diagnosis and prognosis can be obtained by it.

For testing the perception of sound through the cranial bones, the watch, the acoumeter, and the tuning-fork have hitherto been used.

Testing with the watch, as a weaker instrument, cannot be dispensed with in cases in which it is required, not only to ascertain whether vibrations are perceived through the cranial bones at all, but also to find out the extent of the decrease in perception. It is therefore to be recommended that, besides testing with my acoumeter, use should also be made of a low-ticking watch. If such a watch is perceived, it may be inferred that the perception of the Auditory nerve is intact. If the watch is not perceived, while the acoumeter is heard distinctly, a decrease in the power of perception may be inferred ; if even the strokes of the acoumeter are not at all noticed, a severe affection of the perceptive apparatus may be assumed.

Testing with the watch is effected, after the meatuses have been closed by the patient, by pressing it first to the temples, then to the

mastoid processes, or upon the teeth. At this point the watch is heard loudest, less loudly at the forehead, the parietal bone, and the occiput. In the same manner testing with the acoumeter is carried out by bringing its metal plate into contact with the above-mentioned points. In the greater portion of cases the ticking will be heard by the ear under examination, and occasionally even by the opposite ear.

As is well-known, the power of perception through the cranial bones is diminished in old age to a varying degree. This is not due, as was previously supposed, to the decreased conduction of the cranial bones, but chiefly to the material changes which the auditory nerve undergoes through senile degeneration. After the fiftieth year cases are not infrequent in which a low-ticking watch is not heard through the cranial bones; after the sixtieth year the cases are rare in which it is still heard. In aural patients over fifty years of age, who do not perceive sound through the cranial bones, the same importance cannot be attached to those imperfections as in younger individuals.

The utilization of this method of testing as regards diagnostic and prognostic inferences can only go so far as that in a case of middle ear affection which has been diagnosed from objective symptoms, a complete failure of perception for the watch or acoumeter by bone conduction proves an accompanying lessening of the perception in the auditory nerve. This method has a positive value, according to my observation, only in such cases where the ticking of the watch is well perceived by means of bone conduction, although the perception for the watch, the acoumeter (air-conduction), and speech is markedly diminished. In these cases we may say, although only in connection with the results of the tuning-fork tests, very probably the deafness is due to a hindrance of sound-conduction, and not to a labyrinth affection. This method of testing has also a practical value inasmuch as the prognosis of a case where the perception for a weakly-ticking watch by bone conduction exists will be much better than in one where the perception is diminished or completely extinct. The return of the perception by bone conduction, which has been lost through acute middle ear inflammation, concussion of the labyrinth, or syphilis of the labyrinth, is a very favourable prognostic symptom.

In conclusion we will mention the rarely observed intermittent perception through the cranial bones. The phenomenon that on some days the watch is heard well through the cranial bones, while on others the perception is completely wanting, occurs in acute as well as in chronic affections of the middle ear, but is more rarely seen in labyrinth affections. In such cases the

fluctuations in the power of perception of the auditory nerve are produced partly by already existing anatomical changes, partly by an alteration of the tension in the tympanic cavity, and by its secondary influence upon the labyrinth.

2. *Testing with the Tuning-fork.*

(*a*) *Testing the Duration of Perception through the Cranial Bones.* —Schwabach first found that in hindrances to sound-conduction, following disease of the external or middle ear, a vibrating tuning-fork brought into contact with the cranial bones, would be heard longer than by the normal ear. On the other hand, in disease of the auditory nerve apparatus, the perception is shortened in comparison with the normal ear. We possess by this means, although the symptoms are not always present, a method to prove a changed perception of the auditory apparatus in pathological cases.

The tuning-fork which is most used to test for bone conduction is c^2 (512 v.); to test for the higher tones different tuning-forks, from c^4 to c^7, are used. The deep-toned tuning-forks are not suited for this examination, as the greater excursions of the prongs of the fork are transmitted as a concussion to the cranial bones, and may be mistaken by the patient for a sensation of sound. For this reason one should use a well-made tuning-fork, c^2, which is not only free from over-tones, but also communicates no concussion to the cranial bones.

The duration of perception through the bones of the head is proved in two ways, according as, in special cases, a shortened or lengthened perception is sought for. In the latter case, the examiner places the vibrating tuning-fork on his own mastoid process. At the moment when he fails to hear it, he places it on the mastoid process of the patient, and notes the number of seconds which it continues to be heard. If the duration of perception is found shortened, the tuning-fork is first placed on the mastoid process of the patient, and, at the moment when he fails to hear it, brought directly in contact with the mastoid process of the examiner, and the number of seconds noted until it ceases to be heard. In one-sided ear affections, or where both are affected but one to a less extent than the other, this method will give an unreliable result, as the perception in the better or normal ear will lead to improper answers by the patient. It is to be noticed that, according to Siebenmann, the duration of perception for the lower tones of the tuning-fork are shortened by Valsalva's and Toynbee's experiments.

Although, from my observation, this method cannot be relied upon

alone for differential diagnosis between middle ear and labyrinth affections (inasmuch as in middle ear disease which is complicated by labyrinth affection the duration of perception is very much shortened), as a diagnostic and prognostic sign, it is an important symptom. As a diagnostic symptom it supports the conclusion of a hindrance to sound conduction when there is a lengthened duration of perception (negative Rinne), and on the other side, when there is a shortened perception (positive Rinne) with great deafness for speech, the diagnosis of disease of the auditory nerve is made more certain.

With lengthened duration of perception the prognosis in regard to the course of the disease will be much better than in those cases in which it is much shortened. In the latter case a disease of the auditory nerve will be so much the more certain the greater the difference in time between the loss of perception on the mastoid process of the diseased and of the normal ear.

(*b*) *Weber's Test.*—Testing of the lateralization of the perception of the tones of the tuning-fork from the median line of the skull, E. H. Weber first found that a vibrating tuning-fork set upon the skull will be pre-eminently heard in that ear the external meatus of which is closed by the finger. The increased sound perception is produced (1) by the increased resonance of the external auditory meatus; (2) by reflection of the waves of sound transferred through the cranial bones to the air of the external meatus upon the membrana tympani and the ossicula; (3) by the altered tension of the membrana tympani and the ossicula * (Politzer). According to Bezold, the excessive tension in the bands of the ossicular chain in middle ear affections produces the increased perception for the vibrations of the tuning-fork through the cranial bones.

The Weber test has proved, in combination with other methods of testing, a valuable assistance in the diagnosis of ear diseases. Clinical observation shows that in the majority of cases of unilateral ear disease, where the sound conduction to the labyrinth is hindered by pathological changes in the external meatus or middle ear, a vibrating tuning-fork placed on the middle line of the skull will be heard most markedly in that ear where the pathological change occurs. It must of course be understood that the labyrinth is not at the same time affected so that the vibrations of the tuning-fork can no longer be perceived through the auditory nerves.

The same is also often observed in affections of both ears of different intensity, yet in these cases there are many exceptions, as

* Compare my discussion, 'Ueber Schalleeitung durch die Kopfknochen' (*A. f. O.*, vol. i., p. 318).

the tuning-fork may be heard better by the less affected ear instead of by the more affected one.

On the other hand, in disease of the auditory nerve apparatus, provided it is not complicated by an affection of the external or middle ear, the tuning-fork, when held on the middle line of the skull, will be heard more loudly in the normal ear.*

The best tuning-fork to use for Weber's test is c^2 (512 v.) which is free from over-tones. When the results are not satisfactory lower toned forks may be used, but higher toned tuning-forks should not be used for this test, as they often give an exactly opposite result to c^2 and lower toned ones.

The Weber test is carried out as follows: holding the tuning-fork by the handle, and striking one of the prongs on an upholstered piece of wood, or on the palm of the hand, the handle is set on the median line of the skull. As the test from the vertex often gives no positive result, it is better then, in such cases, to press the handle either on the median line of the upper lip, against the incisor teeth, or on the median line of the lower jaw, from which place the increased sense of sound will more often be correctly located than from the vertex (Edwin v. Milligan).

In questionable results the sound will prevail in one ear distinctly if the end of an otoscope is inserted into both ears. The answers of the patients are of most importance when the tone perception predominates in one ear in unilateral ear affection, it is of less importance when both ears are affected. In these cases, especially with double chronic middle ear affections, the tuning-fork is heard equally on both sides, or more distinctly on one side from the vertex and on the other from the maxillæ or base of the nose.†

* The increased perception of the tuning-fork through the cranial bones in the affected ear in unilateral ear affections, was known to the older ear specialists, but was regarded as due to obstruction of the external meatus, tympanic cavity and labyrinth (E. Schmalz, *Erfahrung über die Krankheiten des Gehörs*, Leipzig, 1846). My observations for thirty years show, that in cases of undoubted labyrinth disease, as in apoplectic Menière's disease, in auditory paralysis from concussions of sound, in cases of syphilis of the labyrinth, etc., if they are not combined with a middle ear disease, the tuning-fork (c^2) without exception is localized in the normal ear. This fact is not refuted by the observations of Jacobson, that in a traumatic labyrinth affection, the tuning-fork was heard more loudly in the affected ear, as in such cases a complication may exist, of a change in the chain of ossicles produced by the trauma. As little dependence can be placed on the cases observed by Burckhardt-Merian and Hartmann, where the cochlea were exfoliated on one side with lateralization of the tone of the tuning-fork in the diseased ear, for these cases are always associated with middle ear disease, and the perception is received through the saccule of the vestibule and the ampullae.

† If, as I first showed, the finger be placed in the meatus of the normal ear in unilateral hindrance to sound conduction, the increased sound perception will spring from the affected ear to the normal one, and upon removing it will return to the affected side again. It is, therefore, proved that the preponderance of sound perception in one ear is able to suppress the sound perception in the other ear, in spite of an equal conduction of sound to both ears.

From the parietal eminence the tuning-fork may be heard in the opposite ear even when normal.

The Weber test possesses a diagnostic value only in those cases where the positive statement of the patient shows that the vibrations of the tuning-fork from some one point on the middle line of the skull preponderates in the affected or more affected ear. We can then conclude that there is a hindrance to sound conduction. On the other hand, the statement that the sound of the tuning-fork predominates in the better hearing or normal ear has little value, as this may occur either in middle ear or labyrinth affections. In the latter case, it is only to be considered a diagnostic symptom when in connection with a series of other symptoms which will be stated later.*

The results of testing with the watch and tuning-fork are often opposite, as on that side where the perception of the tuning-fork, from the vertex, prevails, the watch pressed upon the temple of the same side will not be heard, or only much weaker than in the other ear. The reason for this, according to my view, depends in greater part on the different intensity of sound of the watch and tuning-fork, as often in such cases if a metronome, the strike of which is like the ticking of a watch many times increased, be placed upon the vertex, it will be heard more loudly in the diseased ear. The difference in pitch of the tones should also be considered, as in failure of the upper tones, the high over-tones of the watch will not be heard (Bezold).

(*c*) *Rinne's Test.*—Combined testing of air and bone conduction.—If one holds a vibrating tuning-fork on the mastoid process or other portion of the skull until the tone is no more heard, and then holds the prongs near the ear without striking again, it will be heard anew in the normal state of the ear. This is called the positive Rinne test.

In a paper on physiology† in 1855, Rinne brought forward this test as of general diagnostic value, for he stated that in those disturbances of hearing in which the tuning-fork is heard through the cranial bones longer than before the ear, a disturbance of the sound-conducting apparatus exists. This is known as negative Rinne or, as the author proposed, 'disproportionate.'‡ Where, on the contrary, the tuning-fork is perceived longer before the ear than through the cranial bones (positive Rinne) it indicates, according to Rinne, a disease of the auditory nerve apparatus. To Lucae belongs the honour of applying this test in practice, which was unnoticed until then. Its

* Compare Gellè, *De la valeur semiotique de l'epreuve du diapason vertex, Congressbericht*, Basel, 1885.

† Prager *Vierteljahresschrift*, vol. i., 1855, p. 72.

‡ I proposed this name (ausfallender), as it is clearer for those not specialists than the word 'negative Rinne,' by which a positive result, however, is understood.

diagnostic significance has been demonstrated by means of sections from Politzer,* Lucae, Bezold, and others.

Although the diagnostic value of this test is limited, yet in a series of cases it affords valuable assistance in so far that often, when other symptoms are lacking, Rinne's test will establish the diagnosis between middle ear and labyrinth disease. This test must always be considered in connection with the general results of the examination, especially to the amount of deafness for speech, the duration of perception for the tones of the tuning-fork through the bone (p. 143), and to the perception of high and low tones.

The general results of this test may be summed up as follows:

1. Rinne's test is of important diagnostic assistance in those cases of chronic middle ear affections with marked deafness,† in which the diagnosis cannot be made by other methods of examination. The Rinne test is in the majority of these cases negative, provided that no deeper complication, with an affection of the auditory nerve, is present.

2. The negative Rinne speaks so much the more for hindrance to sound conduction the greater the difference in time between the duration of perception for the tuning-fork before the ear and from the mastoid process. This diagnosis will be supported by the failure to perceive low tones and the relative better perception for the higher tones; farther, by the lengthened perception of the tone of the tuning-fork through the cranial bones (Schwabach). In unilateral deafness the negative Rinne will be supported in the diagnosis of hindrance to sound-conduction if at the same time, in Weber's test, the perception is localized on the diseased side.

3. In middle ear affections in which there is only slight or a moderate amount of deafness, Rinne's test has only small diagnostic value, as in the majority of these cases it gives a positive result. This is very often the case in purulent middle ear inflammation, with perforation of the membrana tympani.

4. In middle ear affections with a slight amount of deafness, the diagnostic value of Weber's test is to be placed above the Rinne test.

5. In old individuals, in which the duration of perception through the cranial bones is shortened (Liebermann), Rinne's test often gives no positive result.

* Brunner, *Z. f. O.* vol. xiii., p. 263; Bezold, *Erklärungsversuch, Z. Verhalten d. Luft und Knockenleitung beim Rinne'sehen Versuch*, Munchen, 1885; Roosa, *Archives of Otology*, 1884; Emmerson, *Z. f. O.* vol. xiii., p. 53; Schwabach, *Z. f. O.* vol. xiv., p. 64; Politzer, *Bericht d. Vers. suddeutscher und schweitzer Ohrnärzte*, Munchen, 1885; Eitelberg, *Z. f. O.* vol. xvi.; Rohver, *Monograph*, Zurich, 1885.

† According to Lucae, Rinne's test can only be relied upon when the hearing distance has decreased to 1m. for whispering.

6. In cases of chronic middle ear disease which are complicated by affection of the auditory nerve, the result of Rinne's test often remains undecided.

7. When, in severe deafness, the Rinne test gives a positive result, it leads one to diagnose an affection of the auditory nerve, especially if at the same time the results of the examination, causes, course, and symptoms speak for disease of the auditory nerve apparatus. The diagnosis will be supported by the marked decrease of perception for the higher tones, with, at the same time, a relatively good perception for the lower tones and a shortened duration of perception for the tuning-fork through the cranial bones.

8. Clinical observation shows that the Rinne test may be positive in middle ear affections with great deafness, and negative in severe forms of labyrinth disease. This fact does not detract from the general value of this test, if it is used in combination with other methods of testing to arrive at a diagnosis.

The c^2 tuning-fork is specially suited for Rinne's test, yet one can use besides c^3 and c^4. High-toned tuning-forks may interfere with the result in so far that the air conduction cannot be entirely eliminated. Testing with low-toned forks is to be avoided, as the concussion on the cranial bones may be mistaken for a tone perception. With every tuning-fork the duration of Rinne's test is to be established in seconds by the average results in normal ears.

The test is performed in two manners: 1. The vibrating tuning-fork is held before the ear until the patient says he fails to perceive it, when immediately the handle is placed on the mastoid process, and the patient signifies when the vibration ceases. The difference in time between the perception from the air and through the mastoid process must be measured in seconds and noted. This procedure is generally observed in hindrances to sound conduction. 2. The vibrating fork is first placed upon the mastoid process, and as soon as it fails to be heard is placed in front of the ear, and the difference in time between the perception upon the mastoid process and before the ear is measured in seconds. This is the method of testing for positive Rinne. If in the same case different results are obtained from testing by the two methods, the average should be taken as the result (Bing). Things which interfere with the examination by Rinne's test are the occasional after-tones of the tuning-fork in the ear and perception of the tuning-fork in the opposite ear. The latter may generally be avoided by holding the tuning-fork parallel instead of at right angles to the mastoid process.

(*d*) *Gellé's Test.*—Pressions centripètes.—If in the normal ear the air be compressed by means of Siegle's speculum, or with a balloon provided with an olive tip, the tone of a tuning-fork placed on the vertex will be greatly diminished. This decrease is the result of increased labyrinth pressure, as by this means the membrana tympani

and the chain of ossicles, with the plate of the stapedius, are pressed inward. There is no question that the tension of the sound-conducting portion produces the weakening of the sound perception. If in a case there is hindrance to sound conduction—for example, an anchylosis of the stapes—the tone of the tuning-fork, according to Gellé, will remain unchanged during the test; but if the labyrinth is affected and the stapes movable, the tone of the tuning-fork will be diminished by every condensation of air in the external meatus, as in the normal ear. Besides this, in labyrinth affections a more or less pronounced dizziness will be produced by the increased pressure in the labyrinth.

Cessation of perception for the tuning-fork and unreliable statements of the patients interfere with the application of this method of examination.

Gellé's test is generally only of value in the severer grades of deafness, as it is only in these that a positive result is given (even in these not constantly). This test is of little value in deafness of slight degree, as in slight middle ear affections the tone of the tuning-fork is diminished when the air is condensed in the external meatus, as in labyrinth affections. Gellé's test agrees with the result of Rinne's experiments very often (according to Rohrer in seven-tenths of the cases). Where, by means of Rinne's test alone, or in combination with other methods, a diagnosis is positively made, the use of Gellé's test may be dispensed with. On the other hand, it is to be remembered that in certain cases where the other tuning-fork tests give no certain result in severe grades of deafness, the Gellé test will occasionally give a positive indication. I will here mention the diagnostic point, that in cases where a slight pressure produces dizziness, the diagnosis of auditory nerve affection is sustained. Dizziness and diminution of the tone of the tuning-fork in Gellé's test may, however, be absent in labyrinth affection.

There remains yet to mention Bing's method of differential diagnosis between middle ear and labyrinth affections, which consists in the fact that a vibrating tuning-fork held upon the mastoid process after the tone ceases to be heard, by closing the external meatus with the finger will be heard anew. In pathological cases, according to Bing, one may be certain of hindrance to sound conduction if, on closing the meatus, the tone of the tuning-fork is not heard again; if it is heard again after closing the meatus, it signifies an affection of the labyrinth. Only in cases of severe deafness from hindrance to sound conduction does this method give a positive result; in slight cases of middle ear affections and in disease of the labyrinth it generally fails.

Corradi (*A. f. O.*, vol. xxxii.) found that the tone of a tuning-fork could again be heard after the perception had ceased by removing it from the mastoid process and again replacing it in the same position. This returning again of the tone-perception after it has disappeared should be repeated (3-4 times) by removing and replacing the tuning-fork. The first tone-perception Corradi called primary, the following secondary. In difficult hearing the presence of secondary perception indicates the presence of a middle ear affection, and the lack of it indicates a labyrinth affection. The confirmation of these statements must be waited for.

I will here make a few remarks regarding the understanding of speech through the cranial bones. I have ascertained that by filling both meatuses with glycerine and closure of the mouth and nostrils, whole sentences will be understood at the distance of $\frac{1}{2}$ m. (*A. f. O.*, vol. i., p. 350). The pathology of middle ear affections, especially anchylosis of the stapes, shows us the fact that, if the vibrations of the membrana tympani and the ossicula are obliterated, articulated tones are still heard. That in these cases the waves of sound are transmitted through the cranial bones and not by the means of the air in the cavum tympani to the labyrinth is proved by the fact that words spoken through the speaking-tube are not understood, but words spoken loudly near the ear are still heard.

That the understanding of speech as well as the hearing of musical tones in hindrances to sound conduction in the middle ear by means of the cranial bones and other solid portions of the body is possible, is shown by the cases reported in the older literature of ear diseases. To these belong those persons of difficult hearing who hear a series of musical notes only indistinctly and without connection, while if they are in connection with the source of the tone (for example, connected to a piano by means of a rod held between the teeth) whole tunes are heard as plainly and distinctly as when their hearing was normal. I have seen cases of severe deafness resulting from a chronic thickening of the lining of the cavum tympani who only hear speech, with their eyes closed, if the hand of the speaker be placed upon the head or shoulder.

I will only mention here a method given by me to test the condition of tension of the sound conduction apparatus by means of an auscultation tube with three branches as well as the interference-otoscope of Lucae for the same purpose. As even in the normal condition, both membrana tympani reflect the waves of sound with unequal intensity, and other conditions, as different width of the meatuses and unequal position of the tip of the tube, etc., go to influence the results of the examinations, the value of this method, which is very good for some cases, is much diminished. For the more complete understanding of the subject refer to my paper on sound conduction through the cranial bones (*A. f. O.*, vol. i.), and to the paper by Lucae (*A. f. O.*, vol. iii., p. 186).

Dr. Bing has given for several years an assistance to diagnosis which he calls the 'entotic' use of the speaking-tube. He designates thereby the speaking in the funnel of a speaking-tube the other end of which is connected with the cavum tympani directly by means of fitting into a catheter introduced in the Eustachian tube. In this way the waves of

sound pass through the speaking-tube, catheter, and Eustachian tube into the cavum tympani, where they reach the footplate of the stapes and the fenestra rotunda, and by them are communicated to the fluid of the labyrinth and the auditory nerve. In a case where speech is not heard through a speaking-tube in the external meatus but by the 'entotic' use of the same is easily understood, according to Bing there is certainly a hindrance to sound conduction in the malleus or incus, and the footplate of the stapes is freely movable in the fenestra ovalis.

C. *Method of Examining the Patient.*

A thorough examination of the patient is an indispensable postulate for the making of a correct diagnosis and determining the prognosis and the proper treatment. Examination of the patient is divided into the history and subjective symptoms of the patient, and the objective examination.

The record of the statements of the patient in regard to the course of the disease is very important. While in certain cases the diagnosis may be made without a detailed record of the history by means of the objective examination of the patient, it is in the majority of cases absolutely necessary to take into consideration the history of the pathological changes, as it is only by it, in connection with the objective results, that a diagnosis of the affection as well as a prognosis is rendered possible.

When inquiring into the history of a case, it is specially important from a prognostic point of view to find out the duration of the ear-disease, as the prognosis will be generally the more favourable the shorter its duration. In cases in which disease of the ear has suddenly developed without any previous affection of this organ with striking subjective symptoms, or when the affection is produced by some prominent cause (acute eruptive fevers, typhoid, trauma), we generally receive reliable statements regarding the commencement of the disease, but many patients are not even able to fix the date of the beginning of their disease approximately. The latter happens especially in those cases of unilateral insidious affections of the ear, which are developed without striking subjective phenomena, without pain or subjective noises, and unnoticed by the patient. These are generally dated only from the time when, during the closure of the normal ear, the functional disturbance of the diseased ear has been accidentally found out. But also in such cases affecting both ears the functional disturbance will be noticed only when it has reached such a degree as to interfere with conversation, especially in persons whose position or calling makes no great demands upon their hearing, and who therefore hardly notice any

trifling impairment. The commencement of a disturbance of hearing, which has already existed unnoticed for a long time, may also be dated from the appearance of the subjective noises; indeed, not unfrequently patients are examined who state that their ears have been affected for only a short time, while objective examination shows extensive loss of substance, chalky deposits, and cicatricial formations, which have existed for a long time without the person in question having the least idea of any affection of the ear.

No less important from a prognostic point of view is the determination of the cause of the ear disease, as the prognosis is quite different in genuine disease of the ear than in those produced by scarlatina, syphilis, and other general diseases.

The diseases of the ear are either produced by influences working directly upon the ear, through general affections, or diseases affecting other organs adjoining.

Of the causes which directly set up mischief in the ear, we must in the first instance consider injuries, the excessive action of sound upon the organ of hearing, scalds, burns, frost-bite, and lastly, vegetable parasites (aspergillus), in the external meatus.

Of the causes which come into play by means of continuity and contiguity of tissue, due prominence must be given to the acute and chronic naso-pharyngeal affections (hypertrophy of mucous membrane of the naso-pharynx, adenoid vegetations, polypi, ozœna, etc.) which cause functional disturbances of varying extent by spreading to the middle ear. A large number of the cases are produced by an infection of pathogenic microbes, extending from the naso-pharynx, as has been shown by recent investigation. Less frequently is the ear affected by external disease, as, for instance, by erysipelas and eczema of the skin of the face and head.

Among the immediate causes, even if not always demonstrable, we must count the atmospheric influences which are commonly called 'colds.' We are only justified in considering the 'cold' as the cause of the ear disease if the disease occurred shortly after the exposure of the ear to a cold wind or cold water, or exposure of the body to wet and cold. Patients often use the word 'cold' for an unknown and only supposed cause of the ear disease.

Affections of the ear are also developed sometimes in the course of general diseases, or diseases of special organs. To the former class belong scarlatina, measles, small-pox, typhus, syphilis, diphtheria, mumps, rachitis, Bright's disease, diabetes, leukæmia, tuberculosis, scrofula, acute rheumatism, and gout; to the latter, pneumonia, puerperal processes, and a number of affections of the circulation, such as are caused by valvular defects, aneurism, struma, attacks of

hooping-cough, gravidity, and anomalies of menstruation. Besides, inter-cranial processes, meningitis simplex, meningitis cerebro-spinalis epidemica, hydrocephalus acutus and chronicus, apoplexy, encephalitis, sclerosis of the brain, and tumours of the brain (Benedikt); also tabes dorsalis, and hysteria, are the cause of disturbances of hearing of different degrees, partly by the extension of the pathological processes to the ear itself, partly by affecting the trunk of the auditory nerve. In conclusion, we must mention certain drugs, like quinine, salicylic acid, and others, which, when taken internally, produce temporary or permanent disturbances of hearing, as also chronic poisoning, occurring in various industries, from lead, arsenic, phosphorus, etc.

Another important cause has to be added to those already enumerated, viz., hereditary predisposition. As is well-known, hardness of hearing is hereditary in many families to the extent that either all the members, or several of them, are afflicted with it. The affection appears either in the immediate descendants, or, according to my experience, more frequently in the second generation. But we are only justified in assuming hereditary predisposition as the cause of the aural affection, when in several members of the same family the disease of the ear has developed with similar symptoms and without other demonstrable cause.

If, according to the foregoing, we are often enough in a position to trace the causes of the affection of the ear to one of the above-named sources, we must, on the other hand, confess that very frequently the cause is not to be defined. This refers not only to a number of acute inflammations of the external and middle ear, accompanied with free exudation, but especially to those insidious affections of the middle ear which are developed without striking symptoms and with a gradually progressing functional disturbance. But this is by no means surprising if we consider that medical science is still generally in darkness regarding the pathogeny and determination of the causes of disease, especially chronic affections.

Another point to be considered during the examination of the patient is his calling and occupation, inasmuch as in the curable forms of acute and chronic inflammations of the middle ear, the chances of complete recovery are much smaller in persons who are obliged to expose themselves during the course of the disease to unfavourable influences connected with their occupation, than in those who are in a position to avoid any external disadvantage.

The unfavourable influence of occupation upon affections of the ear is especially prevalent among certain classes; for instance,

coachmen, masons, tanners, fishermen, sailors, soldiers in the field, etc.—in a word, among persons who are continually exposed to all the vicissitudes of the weather. It is just as certain that the affections of the ear, associated with subjective sensations and an irritated or paralytic state of the auditory nerve, are influenced in a detrimental manner by noises in certain occupations continually acting upon the organ of hearing. We observe, for instance, in locksmiths, blacksmiths, millers, coopers, workers in noisy factories, and so on, in consequence of the excessive irritation of the auditory nerve, an obstinate continuance of the subjective noises, and an increase of the same, as well as of the deafness.* That climate, the condition of the dwelling, the mode of life of the patient, the excessive indulgence in spirits, smoking and snuffing tobacco, etc., influence the course of affections of the ear, requires no further proof.

It is also important to note the mode of development and the course of an affection of the ear, as they not unfrequently permit of a conclusion as to the nature of the disease. It is, therefore, necessary to find out in every case whether the disease has arisen with acute inflammatory phenomena, or without them, with rapid decrease of the function of hearing, or whether the disease has taken a slower, insidious course, with gradually increasing deafness.

We must likewise learn whether the power of hearing varies to any considerable extent or not. For experience teaches that great fluctuations in the hearing-distance are generally observed in secretive inflammations of this cavity capable of resolution; but that in the insidious inflammations of the middle ear, unaccompanied by swelling and secretion, which cause permanent disturbances of hearing by the fixture of the ossicula, the hearing is subject to only very slight fluctuations.

A few remarks may here be made from a prognostic point of view regarding the frequency of the diseases of the ear at different ages, and the influence of age upon the course and issue of the disease.†

* That occupations which are associated with continuous noise not only act unfavourably upon already existing affections of the ear, but cause ear disease, is beyond doubt. In the investigations which I undertook in regard to this with different tradesmen, I found that, next to the locksmiths, coppersmiths and coopers were most afflicted by disturbance of hearing. Upon the latter especially, according to their own statement, the so-called hollow stroke when hooping the casks is said to have such a deafening effect, that most of them, if they remain at their trade, become hard of hearing in time.

† Weil found among 5,905 children about 30 per cent. with deafness of different grades, and Bezold among 3,826 children about 20 per cent. with deafness. These have, however, only a local value, as the results of statistics for different climates and other local peculiarities are certainly very different, which accounts for the great

Soon after birth, the transformation-process in the middle ear, the rapid formation of mucous membrane there, and the action of external injurious agencies upon the hyperæmic mucous membrane of this cavity, favour the origin of inflammations. In childhood the acute exanthemata and naso-pharyngeal affections are the chief diseases which frequently become the source of affections of the ear. While the frequency of ear-diseases decreases in the prime of life, it presents again a noticeable increase in advanced age, not only in consequence of retrograde changes in the ear similar to those in the other organs of special sense, weakening the power of the auditory nerve, but also frequently owing to the development of chronic insidious inflammations of the middle ear leading to thickening of the lining membrane of the tympanic cavity and to rigidity of the articulations of the ossicula.

We will now describe a series of subjective and objective symptoms, the importance of which in diagnosis and prognosis must not be undervalued.

Among the subjective symptoms which hold a prominent place in our consideration are the subjective noises, which occur as ringing, knocking, hissing, roaring, whistling, like boiling water, etc. According to my observation, nearly two-thirds of all ear patients suffer from subjective noises in the ear, and the number who come for treatment on account of them is very considerable. Often objective noises (circulatory and muscular noises and mucous rales) will be heard as blowing, snapping, and cracking sounds.

Where, according to the statements of the patients, subjective noises exist, it should be determined whether they are unilateral or bilateral, if they are perceived in the head or in the ear, whether they are endurable or very troublesome, if they have a high or low-toned character, by what things they are increased, and whether the sensation is only occasional or uninterrupted. This is important, for my experience shows that the prognosis is much less favourable

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disproportion between the statistics of Weil and Bezold. According to Bürkner among every 100 cases of ear disease, 73 adults and 27 children, there are 25 per cent. with diseases of the external ear, 67 per cent. with middle ear disease, and 8 per cent. with affections of the auditory nerve. These statistics were made by Bürkner from the annual reports for several years of the different ear clinics and dispensaries of Europe. They can bear no claim to exactness, however, as the differential diagnosis between middle ear and auditory nerve affections was formerly much less exact than at present, and some of the reports are lacking in many important details. In general, ear affections are more frequent among men than women. The left ear is more often affected than the right; according to Löwenberg, unilateral ear affections among men are more often in the left, and among women in the right.

in cases with continual subjective noises than in those where no noise occurs, or only occasionally. One should examine further if the noises in the ear are increased or diminished by diminished blood-pressure in the ear, during compression of the carotid; or if stopping the external meatus with the finger affects the intensity of them; whether the subjective sensations are altered by reflex action from the cutaneous branches of the trigeminus; also through pressure upon the mastoid process; or irritating the skin in the region of the ear; and lastly, if the intensity is decreased by the tones of high or low tuning-forks.

A more rare accompaniment of ear diseases is the pain, which is very intense in acute myringitis, acute middle ear inflammations, especially in children, and in caries of the temporal bone.

Where the patient complains of pain in the ear, we must determine if it is located in the region of the external ear or in the deeper portion; whether it is limited to the ear or extends outward towards the forehead, occiput, or the region of the neck; if the pain is increased by pressure upon the region of the ear, and how often during the course of the disease the pain has occurred, and if it is atypical or in regular paroxysms. Besides, it is important to determine the cause of the pain in every case by objective examination. If we are able to say from an ocular inspection that there is no inflammatory process in the ear, we should investigate whether we have to do with a neuralgia, whether it is located in the external meatus or in the plexus tympanicus, and whether it is a localized ear disease, or accompanies a trigeminus or cervico-occipital neuralgia. One should not forget in such cases to examine the teeth, as, especially in children with carious teeth, the pain radiates to the ear. In the same way, during ulcerative processes in the pharynx and larynx, the pain may radiate to the ear.

To the important ear symptoms should be added dizziness, which occurs not only in disease of the labyrinth and in cerebral deafness, but is often observed in those affections of the middle ear which are accompanied by increased pressure in the labyrinth. These patients should be tested by walking with closed eyes and by turning the body on its long axis. One should observe to which side there is a tendency to fall, and whether by forcing air into the middle ear or aspirating it from the external meatus, the dizziness is increased or diminished.

Lastly, in judging of the symptoms of the disease, one should be careful not to place too much importance on such abnormal sensations as pressure, fulness, etc., in the ear, as these are placed in the foreground by the patient on account of their disagreeableness. To

these also belong the often unpleasant resonance of the patient's own voice, as occurs in unilateral accretions of cerumen and in a swollen or patulous Eustachian canal, and the painful sensation of sound called hyperæsthesia acustica, which occurs in nervous individuals and in slowly progressing cases of chronic ear affection with great deafness.

Of the objective symptoms the first thing to determine is the presence or absence of a discharge from the ears. Where it exists we should question how long this has existed, whether it is copious or scanty, what character it has, purulent, mucous, or bloody, with a bad odour or not, whether it has been uninterrupted since its start, or occasionally stops, also whether a subjective easing during the period of stopping, or, on the contrary, pain and pressure in the ear occurs.

Of less importance, but under certain circumstances noticeable, are the following disturbances of hearing. To these belong the better hearing in a noise, in a waggon, upon the railroad (Paracusis Willisii), which occurs most frequently in the adhesive processes of the middle ear, without secretion, and is therefore to be considered as an unfavourable prognostic symptom. Another symptom, which is seldom spontaneously given, but may be obtained upon questioning the patient, is the paracusis localis, or the impossibility to give the direction of the sound. One observes this mostly in unilateral deafness of a severe type, and it is to be explained by the fact that the judgment of the direction of sound is made possible only by binocular hearing.

An estimation of the facts of the patient's history, already described, as also of the most important symptoms of disease, taken in connection with the results of the objective examination, should in most cases enable one to form a judgment as to the nature of the affection of the ear and its prognosis in any given case. It is now only required to survey, in regard to the methods of examination already discussed, the order of procedure in the examination and inspection of patients.

The objective inspection of the patient commences with the auricle, the external meatus, and the membrana tympani. The neighbourhood of the external orifice of the ear and that portion of the external meatus visible without the speculum must be examined before the introduction of this instrument, because certain changes, confined to this region (for example, eczema, fissures), are covered by the speculum, and might thus be easily overlooked. After the insertion of the speculum, the meatus is examined as to its capacity and curvature, character of its secretion and vascularity; and the

nature of existing obstacles, such as are caused by a natural or abnormal secretion of cerumen, by fungi, polypoid growths, exostoses, or other pathological processes, leading to the stricture of the meatus, is ascertained by inspection, and eventually by probing.

If the inspection of the membrana tympani is not prevented, the different portions of the membrane are examined in regard to colour, lustre, transparency, and curvature, by slightly moving the speculum. The degree and extent of the vascular injection, the size and colour of existing opacities and chalky deposits, the form, position, and extent of perforations, of cicatrices and atrophied places, are ascertained, and the presence of general or partial outward curvature, which may be caused by infiltration, serous and purulent formations, as also by granulations and polypous growths, is discovered. General or partial inward curvatures of the membrane, and their relation to the articulation of the stapes and to the inner wall of the tympanic cavity, must also be taken into consideration.

The position and inclination of the malleus, the size and outward curvature of the short process and of the posterior fold of the membrane, the form and extent of the triangular cone of light, the pathological changes in the tympanic cavity, the colour and extent of exudation shining through, and in case of a perforation, the state of the visible inner wall of the tympanum, must be ascertained. In cases of decided anomalies of curvature of the membrane, as well as those which appear normal, examination with Siegle's speculum, to ascertain the tension and mobility of the membrana tympani, must not be omitted.

After ascertaining the state of the membrana tympani, the function of hearing has to be tested by first finding out the acuteness of hearing for the acoumeter and the watch, the perception for the tone of the tuning-fork through the air, the distance of hearing for speech, and then the power of perception through the cranial bones by means of the watch, the acoumeter, and the tuning-fork (Weber's and Rinne's test, duration of perception through the cranial bones).

Then follows the examination of the Eustachian tube and of the tympanic cavity, by the Valsalvan experiment, by propelling air by means of my method, and if these procedures give no positive result, by means of the catheter. Here the auscultation-sounds in the middle ear, and the changes in the membrana tympani, perceptible after inflation, especially the change of colour and curvature of the membrane, and the position of the handle of the malleus, must be observed.

After examining the middle ear, testing the hearing is repeated

in the above manner to ascertain the difference in the power of hearing before and after inflation. This is of the greatest importance as regards both diagnosis and prognosis. For generally, if a considerable increase in the hearing-distance takes place, it may be inferred that the changes are such as to warrant a favourable prognosis (swelling and secretion in the middle ear, anomalies of tension, etc.), while in cases in which no improvement in the hearing, or only a slight one, takes place after inflation, the prognosis will be more unfavourable, because it may with probability be assumed that the disturbance of hearing is due to some organized and irremovable pathological change in the middle ear, or in the labyrinth.

It is even as important to ascertain whether the subjective noises still remain, after making the Eustachian tube permeable. If there is an important diminution of them, it is a favourable prognostic sign, in that it proves the noises to be partially dependent on changes in the middle ear which are producing pressure upon the labyrinth. When, on the other hand, after forcing the air into the middle ear, the noises in the ear remain unchanged, we may judge that, in most cases, there are changes in the hearing apparatus which warrant an unfavourable prognosis.

According to my experience, great importance should be placed on questioning the patient, whether, in troublesome pressure and fulness in the ear, by placing his finger tightly in the external meatus and repeated shaking, he seeks to rid himself of the disagreeable feeling. We should also question the patient, especially in middle ear affection, if he has used the Valsalvan experiment, as patients often use it without telling the physician in regard to it. Both manipulations have a very bad influence upon the hearing, and the misuse of Valsalva's experiment, if the patient is not warned in time by the physician, will produce severe disturbances in the hearing.

In inflammation of the middle ear, especially in acute and chronic suppuration, examination of the region of the mastoid process is absolutely necessary, because inflammations which have extended to that part produce palpable changes by involving the external osseous wall, the periosteum, or the integument, changes which it is very important to discover in time for treatment to be applied. By a moderate pressure with the tip of the finger it may be ascertained whether there is any enlargement of the bone, any infiltration of the periosteum and of the skin, and whether fluctuation is present; also whether, and to what extent, pressure upon the bone causes pain, in what part of the mastoid process the greatest pain during pressure

is felt, and whether or not a fistulous opening or cicatrix exists. As in inflammation of the external meatus and of the middle ear, especially in purulent affections, the cervical glands and the lymphatic glands on the mastoid process are often swollen and infiltrated, they have also from time to time to be examined, as a decrease in the infiltration may generally be considered as a favourable sign.

After this follows the examination of the naso-pharynx in regard to congestion, swelling, secretion, growths of mucous membrane, ulcerations, and principally in regard to the state of the orifices of the tubes. Referring to the special division on the naso-pharyngeal affections for the details of the examination, we will only remark here that rhinoscopic inspection must be made, especially when the collective symptoms (changes in the portions of the visible naso-pharyngeal structures, increased secretion, palpable obstacles in the naso-pharynx, and difficulty in breathing through the nose) make the instrumental examination advisable. In case of obstacles to the current of air through the nose, our attention is often drawn to the presence of a naso-pharyngeal affection by a peculiar expression of the face of the patient, which arises from breathing through the widely opened mouth.

But while the result of the objective inspection of the ear and the neighbouring parts, together with the history of the case, generally suffices for prognosis and treatment, it is often necessary also to consider the state of the general health. We cannot, however, by any means agree to the proposal of those specialists who urge a minute examination of the organs of respiration, circulation, etc., in every aural patient. Considering the amount of time which is spent in a minute examination of the patient, and in a thorough objective testing of the ear, such an examination of the other organs, undertaken without a special cause, would only be an unnecessary loss of time. The examination will therefore be extended to other organs in those cases only in which either the patient's history (*e.g.*, frequent occurrence of pulmonary catarrh, hæmoptysis, palpitation of the heart, syphilis), or his appearance, etc., make a general investigation appear necessary.

Lastly, one should be careful in determining the treatment for special cases, and use such treatment as has previously been tried by experienced physicians.

For the judgment of the course of the disease, it is important to note down the history, subjective and objective symptoms. The most practical way of noting down these memoranda is to make use of a special printed form, and I will here annex the one which I

No. of Journal. Date.	Name, Age, Occupation, Residence.	Diagnosis.

History.

	Duration.	Cause.	Course.	Pain.	Tinnitus.	Otorrhœa.	Hereditary Predisposition.	Other Symptoms.
Right.								
Left.								

Present Condition.

	Auricle.	Meatus.	Membrana Tympani.	Eustach. Tube.	Proc. Mast.	Naso-pharynx.
Right.						
Left.						

Hearing-distance. Politz. Meth., or Catheter.			Air-conduction for Tuning-fork.		Bone-conduction.			
Before.		After.	By Ext. Meatus.	By Eust. Tube.			Weber.	R.
Right.	Acoum.				Watch.			L.
	Conv.				Acoumeter.		Rinne.	R.
	Whisp.	Speech.			Tuning-fork.	Length-ened.		L.
						Short-ened.	Galton.	R.
Left.	Acoum.				Watch.			L.
	Conv.				Acoumeter.		High tones.	R.
	Whisp.	Speech.			Tuning-fork.	Length-ened.		L.
						Short-ened.	Low tones.	R.
								L.

Observations :

Treatment :

Course :

Hearing-distance after Close of Treatment.		
Right.	Acoumeter.	
	Conv. / Whisp. — Speech.	
Left.	Acoumeter.	
	Conv. / Whisp. — Speech.	

employ. It is reproduced here somewhat changed in shape, and each page in the octavo shape contains two forms.* When abbreviations, initial letters, and certain signs are employed, which everyone may construct according to his own convenience, the history of a case can be completely inserted into the given space, and can be used not only as a guide during the course of the disease, but also for scientific communications.

* The German lithographed forms can be had in the shape of a book, firmly bound, from Schönfeld, Wien, at the price of 2 fl. ö. W. per 500 forms.

DISEASES OF THE SOUND-CONDUCTING APPARATUS.

SPECIAL PORTION.

I.

DISEASES OF THE EXTERNAL EAR (AURICLE AND EXTERNAL AUDITORY MEATUS).

I. Anomalies of Secretion in the External Auditory Meatus.

Hypersecretion of the Ceruminal Glands, Formation of Ceruminal Plugs.

The secretion of the cerumen, a product of the ceruminal and sebaceous glands, takes place chiefly in the cartilaginous, and only to a small extent at the commencement of the osseous section of the external auditory meatus. In normal conditions the secretion is removed partly by the movements of the jaw, and partly by various manual manipulations. Frequently, however, the cerumen remains in the meatus, thereby forming a plug by which the canal becomes obliterated and the function of hearing mechanically impaired.

Etiology.—The causes of ceruminal accumulation in the external auditory meatus are: 1. Habitual or frequently-recurring hyperæmia of the lining membrane of the meatus, combined with hypersecretion of its glandular elements. 2. Congenital or acquired contraction of the external meatus, preventing the discharge of the cerumen. To the first class belongs the well-marked screw-like twisting of the meatus (Bezold), to the latter the membranous strictures, the hyperostoses and exostoses in the external section of the meatus and the slit-like contraction of the external orifice of the ear caused in old age by atrophy and shrivelling of the cartilage of the meatus. 3. Abnormal nature of the ceruminal secretion, the retention of a tenacious secretion, which becomes matted with the fine hairs of the cutis, favouring the accumulation of the masses formed

afterwards. 4. Improper cleansing of the external meatus, especially in persons who usually allow, when washing, a quantity of water or soap-suds to flow into the meatus, and then insert into the latter a pointed piece of the towel. The liquid ceruminal secretion is thereby pushed from the cartilaginous into the osseous section, and is finally formed into a lump. 5. Eczema, circumscribed and diffuse otitis externa, partial or diffuse desquamative inflammation of the cutis of the meatus, and suppurations of the middle ear, after the termination of which a plug very often forms. 6. Foreign bodies in the ear, on which the cerumen sticks till an occluding plug is formed, collections of powder, coal dust, desiccated portions of plants, etc.

Accumulations of cerumen occur either without any other disturbance or combined with diseases of the middle ear and of the labyrinth. In people with sound ears the plug may attain a considerable size before the hearing becomes notably affected. Such are those interstitial plugs which do not completely fill up the lumen of the meatus, and do not lie upon the membrana tympani. Mechanical disturbance of the hearing only commences when the lumen of the auditory meatus is completely obstructed by secretion, or when the plug rapidly swells during washing, bathing, or perspiration; or lastly, when it is driven against the membrana tympani by shaking (occluding plugs).

Symptoms.—Frequent but not constant symptoms of accumulation of cerumen in the external meatus are: a feeling of confusion and fulness in the ear, subjective sensations of hearing, resonance of one's own voice, sometimes giddiness and vertigo in consequence of the increased intra-auricular pressure, rarely mental depression (Roosa and Ely, *Z. f. O.*, x.), hallucinations of hearing (Rohrer), vomiting, and eclamptic attacks. More or less severe stinging pains in the ear occur only when the plug is very hard, in consequence of the pressure on the walls of the auditory meatus and on the membrana tympani. In such cases, after removal of the accumulation, there is frequently found a circumscribed inflammation of the osseous meatus, rarely of the membrana tympani. That the chemical quality of the secretion can also produce pain is proved in those cases where, after removing the thin layer of soft secretion from the walls of the meatus, the pain stops. Habermann observed in three cases persistent cephalalgia and trigeminal neuralgia (*A. f. O.*, vol. xviii.); Küpper a case of brain irritation following an epidermis plug; Herzog a case of alteration in the action of the heart (*Z. f. O.*, vol. xx.).

The disturbance of hearing varies according to the degree of occlusion, and the apposition of the plug to the membrana tympani.

I have never observed total deafness, even in cases of complete occlusion. When speech cannot be understood, it is probable that there is disease of the middle ear or of the labyrinth. In primary accumulations, the hearing-distance often varies suddenly, especially when the plug swells and shortly afterwards contracts, or when it undergoes a sudden change of position from movements of the jaw. In perforation of the membrana tympani the plug of cerumen may improve the hearing by acting as an artificial membrane (Kiesselbach).

Toynbee (*l. c.*) and v. Tröltsch (*Virch. Arch.*, vol. xvii.) record post-mortem examinations showing enlargement of the external meatus, the formation of apertures in the walls of the meatus, and perforation of the membrana tympani. Although the possibility of such changes cannot be denied, still, judging from the reports of such conditions, I believe that in most cases they have been sequelæ of an exhausted suppuration of the middle ear.

Diagnosis.—By examination with the speculum, and not unfrequently also with the naked eye, the external meatus is seen to be plugged by either a light yellow or dark-brown greasy mass, glistening or dull, which, on being touched with the probe, feels doughy, half liquid, or hard as a stone. The following may be mistaken for ceruminal plugs: purulent masses remaining after an exhausted otorrhœa, mixed with epidermis, cholesteatomous masses, and dried up to a brown crust; dried blood; foreign bodies enveloped in cerumen; and often balls of cotton, which have been pushed too far down, and became brown after a long time.

After its removal, the obstructing plug often exhibits impressions of the external surface of the membrana tympani, the umbo, and the short process. The mass consists either chiefly of ceruminal secretion, or in great part of cornified epidermic cells (Wreden, Cl. J. Blake) epidermic plates closely packed together or spirally arranged (Bezold), and uprooted hairs, with a slight mixture of cerumen and cholestearine. In many cases it is less of a hyper-secretion of the ceruminal glands than a pathological desquamation of the epidermis of the external meatus (Löwe). The ceruminal secretion contains different fungi (Ebert), and according to the investigations of Rohrer, saprophytic and pathogenic bacteria.

Prognosis.—In regard to the restoration of the function of hearing, this is favourable only when the deafness took place suddenly after a bath or washing, because then the probable cause of the disturbance of hearing would be a primary ceruminal plug. When this is not the case, one must be very careful in giving a prognosis, in view of the fact that accumulation of cerumen is very often associated with the adhesive processes in the middle ear, or with disease of

the labyrinth (according to Toynbee, 160 times out of 200 cases). When the tuning-fork is heard better in the occluded ear it must not be accepted as a sign of the occlusion, as this is also observed, as a rule, in diseases of the middle ear. If, on the other hand, the tuning-fork is perceived through the cranial bones by the better-hearing ear, it is very probable that there is a complication with disease of the labyrinth. Yet in some rare cases of primary plugging of the meatus with cerumen the tone is localized in the normal ear.

Treatment.—The removal of the ceruminal plug is most surely effected by forcibly syringing with warm water; the syringe employed should be large, capable of holding 100 to 200 grammes, and the accumulation will be the more rapidly got rid of if the rounded india-rubber nozzle, or the attachment with short drain, be fixed on the syringe and pushed up to the accumulation. Tenacious plugs may be loosened by means of a sound.

Immediate syringing on the first examination is indicated only when the plug has a glistening greasy appearance and feels soft on being probed. On the other hand, when the cerumen appears lustreless, dry, and hard, it is better to soften it by the instillation of warm water, weak glycerine, or oil into the ear, but a solution of soda and glycerine is best (sodæ bicarbon. 0·5, aqua dest. glycerine pur. āā. 5·0 S. ten drops to be warmed and poured into the ear 3 times daily). After twenty-four hours the cerumen is so soft and loosened that it comes out after a few injections. When the cerumen cannot be removed after repeated syringing it is better to continue the instillation, because by frequent and violent injections otitis externa may be excited. When the drops are prescribed the patient's attention should be drawn to the fact that the deafness will increase, in consequence of the swelling of the cerumen.

After the removal of primary ceruminal accumulations the function of hearing, as a rule, becomes immediately normal and the subjective symptoms disappear. It is only in exceptional cases that slight deafness remains for a few days, in consequence of the long-continued pressure on the membrana tympani, but that quickly disappears when the latter has attained its normal tension. After syringing, it is necessary, as a protection from cold, and particularly in winter, to close the ear with cotton-wool.

In the majority of cases after the removal of one mass another accumulates. The interval between the recurrences varies from several months to several years. There are cases, however, in which the meatus becomes plugged with secretion in five or six

weeks. The accumulation of secretion follows especially rapidly in seborrhœa. In such cases the patient should be instructed in the use of the syringe, and advised to use the drops and injections at stated intervals.

A decrease or an entire cessation of ceruminal secretion is often observed after the cessation of otitis externa diffusa or circumscripta, after eczema, and especially so in the insidious adhesive processes in the middle ear (v. Tröltsch). The cause appears to lie in an affection of the trophic nerve of the ear accompanying the disease of the tympanum. Also in recent catarrh of the middle ear the secretion sometimes disappears, but returns again when an improvement has been gained by treatment. Upon this is based the assumption that the return of secretion is a favourable sign. This is, however, contradicted by the fact that often during treatment of chronic adhesive processes in the middle ear the secretion returns without any improvement in the hearing. The ceruminal secretion seldom completely ceases for any length of time when the state of the external and middle ears is otherwise normal. This anomaly is mostly found in old people with a dry skin, and in persons who habitually wash out the auditory meatus. Examination shows the cartilaginous section free from cerumen, pale and dull. The want of cerumen is often accompanied by itching of various degrees, a feeling of dryness, and contraction in the ear.

The treatment consists in painting the cartilaginous meatus with a small quantity of vaseline, with unguent. præcip. alb. (0·2 : 10), or with a mixture of tinct. nuc. vom. and glycerine (2 : 20) occasionally.

II. Diseases of the Skin of the External Ear.

The skin covering the external ear may be the seat of a localized skin disease, or it may form part of a general skin disease affecting the whole body or larger portions of it. We will here describe only those diseases which occur most frequently, and are of most importance to the ear specialist.

A. *Hyperæmia of the External Ear.*

Acute hyperæmia of the auricle is caused either by mechanical irritation, the action of cold (frost) or heat, or it is the expression of an engorgement of the cutis remaining after exhausted eczema and erysipelatous inflammation. Also the erythema exsudativ. multiforme, which, according to Hebra, is a true exudative process of the skin, may be present on the auricle in all forms, from a simple formation of spots to the development of the so-called herpes-iris-efflorescence, but is usually part of a general erythema upon other parts of the body. A rare form of passive hyperæmia of the auricle occurs as a local cyanosis of angio-paralytic nature, with blueness,

turgescence and coolness of the auricle, occurring in young individuals, who are usually neuropathic and hysterical, and especially during the changes of puberty.

In isolated cases occurs a fluctuating hyperæmia of the auricle, which is to be regarded as an angio-neurosis referable to the sympathetic nerve. Hyperæmia occurs in these cases generally unilaterally, less frequently bilaterally, and especially in the evening with great redness and warmth of the auricle, and with a burning sensation, to which are often added tinnitus aurium, giddiness, and slight faintings. Those quickly evanescent conditions, returning at irregular intervals, appear sometimes in individuals with sound ears, oftener, however, in the course of adhesive otitis media (Burnett). For chronic hyperæmia, cold compresses with Goulard's lotion, or aqua plumbi, pencilling with tr. Rusci, followed by dusting with cooling powders (Zinc oxide, Carbon. plumbi, Amyli oryzea, *āā*. 20·0; Pulv. Irid. florentin, 2·0), and anointing the auricle in the evening with vaseline, are recommended, and for the angio-neurotic form galvanization of the sympathetic in the neck.

Hyperæmia of the external auditory meatus regularly accompanies hyperæmia and inflammation in the tympanic cavity and in the mastoid process. It often appears as a sequel to an exhausted inflammation of the meatus, especially to eczema and furuncles, and is also observed in congestion of the head and in inflammation near the ear, especially of the parotid.

Congestion occurs especially in the osseous, less frequently in the cartilaginous portion, and extends, as a rule, to the upper parts of the membrana tympani, and along the handle of the malleus.

Long-continued hyperæmia leads to hyper-secretion of the ceruminal glands, or to abnormal exudation with the formation of a crumbling friable secretion.

B. *Inflammations of the External Ear.*

Dermatitis of the Auricle.

Dermatitis of the auricle is oftenest caused by injury, frost and heat, less frequently by the sting of insects. Sometimes it is observed as an extension of erysipelatous inflammation from the face and head.

(*a*) Dermatitis traumatica of the auricle occurs following many different mechanical influences: to these belong thrusts, blows, falls upon the ear, insect stings, cauterizing, scalding, piercing the ears for ear-rings, and the mechanical irritation of wearing heavy ear-rings. The intensity, duration and extent of the inflammation depends upon the severity of the injury. The grade of the inflammation varies between the slightest form of a transient erythematous process to the development of circumscribed gangrene of the skin. Severe local affections of the skin, which may extend over the cutis

of the whole auricle, follow very often after insect stings (bees, wasps, horse-flies, etc.), or from the sting of muck-flies, by which infective material is inoculated, producing the disease. The treatment should be purely antiphlogistic, and be adapted to the high grade of inflammation (applications of aqua plumbi aceti, or covering with argilla acet. Burowi, diluted in 10 parts of ice-water).

(*b*) Dermatitis erysipelatosa. (Erysipelas auriculæ.) The erysipelatous inflammation often starts from erosions, excoriations, and injuries of the auricle and external meatus through infection by the specific microbe of erysipelas (Streptococcus Erysipelatos, Fehleisen), which finds lodgment in the portion deprived of its cutis. Opportunities for this are given by all forms of moist eczema in erosion, maceration, and formation of fissures by the purulent secretion from middle ear suppuration, and by any solution of the continuity of the cutis. Primary erysipelas of the auricle is rarely seen; it occurs more frequently with erysipelas of the face and skin of the head, the inflammation occasionally extending to the external meatus and the cavum tympani.

The inflammation extends over the whole auricle, and often extends to the region surrounding the ear, the auricle appears greatly reddened, swollen and enlarged, the skin stretched and shining. Occasionally it forms hard, dark red nodules in the skin, or extensive blisters (erysipelas bullosum), which flatten in a short time and discharge a serous fluid. Rarely the affection is limited to the lobulus.

The accompanying *symptoms* of the inflammation are high fever, fulness in the head, dulling of the senses, severe burning, a feeling of tension and pressure in the auricle, occasional twinges, followed later by severe pain.

Course.—In the lighter cases the fever and signs of inflammation subside in a few days, and the ear returns to its normal appearance. Even with a number of bullæ on the auricle, I have seen healing occur in a few days after the bullæ collapsed, as the denuded places are quickly covered with normal epidermis. Only rarely it goes on to the formation of adherent crusts, after the removal of which marked redness remains for some time.

In rare cases of severe inflammation sluggish, subacute abscesses are formed especially on the posterior surface of the auricle, which, if not opened at the proper time, may go on to extensive undermining of the skin of the auricle. Fatal results of severe migrating erysipelas or from gangrene are very rare.

The *treatment* of erysipelas of the ear should be guided by the generally known principles of antiphlogistic and antipyretic treatment.

(*c*) Phlegmonous dermatitis of the external ear is brought about by the inoculation of pyogenic microbes (Streptococcus and Staphylococcus pyogenes) in wounds of the auricular cutis. It begins generally similarly to erysipelas, with localized heat, congestion and swelling of the skin, often with fever like a superficial dermatitis, severe throbbing pain, increasing undefined swelling and prominence of the auricle, together with a doughy soft fulness, extreme sensitiveness of the ear, which occurs in 24-48 hours, showing often a distinct, deep fluctuation on the third or fourth day. This manifests the deep penetration of the inflammatory process and the subcutaneous formation of pus. Incisions made as early and extensive as possible at any portion where fluctuation is shown, with an antiseptic bandage, will soon terminate the inflammation.

(*d*) Dermatitis congelationis auriculæ. The skin of the auricle is specially disposed to congelative inflammation, as its relatively thin cuticular covering and the tightly-stretched and slight amount of subcutaneous tissue to separate it from the cartilage, affords poor protection in its exposed position. All known forms of dermatitis congelationis are observed on the auricle. The acute hypersthenic form, which results from excessive action of cold, especially in the north, with accompanying freezing of the nose, and goes on quickly to partial necrosis and gangrene of portions of skin and the cartilage, may produce loss of part of the auricle. Then the ordinary chronic form, with moderate swelling and redness, and lastly, a circumscript limited dermatitis, the true frost-bite.

These cases sometimes go on to the formation of nodules and excoriations, especially on the elevations which show a poor tendency to heal, and are covered sooner or later with crusts tinged with blood. After the throwing off of these, a desquamation of the skin often remains a long time. Youngish, chlorotic individuals, especially girls with easily excited vascular nerves, are most generally troubled with this affection, which occurs every year at the beginning of cold weather. It is to be noticed that in those persons disposed to this dermatitis, it is not due to the influence of temperature below the freezing-point, but occurs more frequently in low temperature during the autumn, when it is still above the freezing-point, especially from long exposure to the air.

As subjective symptoms, it is important to notice the cutting pain in the auricle, which is felt by exposure in the open air, especially in dry air and severe wind, and the irritating itching, burning, and feeling of heat, causing incessant rubbing and scratching, which occurs when in a warm room and in bed.

Treatment.—The treatment in acute inflammation consists of the

local application of cold, which must be used as long as it is well borne by the patient. In the lighter forms, cold compresses with Goulard's lotion and tincture of opium (200·0 : 10·0), are sufficient; in the severer forms, small ice-bags, or a specially formed Leiter's apparatus, should be used. For the treatment of chronic and subacute forms of dermatitis, due to cold, the washing and rubbing of the ear two to three times a day with water as hot as can be borne, is specially recommended. The careful pencilling of the ear twice a day with iodine collodium, under the control of the physician, will relieve the unpleasant subjective symptoms. Camphor ointment is used with good result in the form of pencilling several times a day with the following: Camp. rasæ 0·20, Cerea albæ 10·0, Ol. lini. 15·0, by which means the unpleasant itching is made better. Where the formation of bullæ or excoriation has laid portions of the skin bare, they should be covered with a layer of ointment (ung. cerussæ, ung. diachyli, ung. oxidi zinci, ung. argent. nitrici), to protect the portion until the spot is covered with a new layer of epidermis. Instead of the ointment to spread upon the ear in processes with formation of crusts and excoriations on the skin of the auricle, the Beierdorff-Unna's zinc and boracic ointment mull is to be preferred, as it adapts itself to the elevations and depressions of the auricle, and will remain many hours in position. It should be changed morning and evening.

The occurrence of efflorescence on the auricle and in the external meatus in the acute exanthemata should be mentioned. This is specially so in variola in the meatus, as it often produces severe ulcers and formation of crusts. Dusting with boric acid and the placing of boric acid lint in the meatus produce the best result.

B. *Inflammation of the External Auditory Meatus.*

The seat of the primary forms of inflammation is the cutis of the external meatus, from which the changes extend but seldom to its cartilaginous or osseous walls. It is situated either in the cartilaginous section, where the glandular element of the cutis is affected, or in the osseous portion of the meatus, from which the more superficial, spreading inflammation frequently extends to the cutis of the membrana tympani. The external meatus in its whole extent is seldom uniformly inflamed.

Otitis externa presents a series of characteristic forms, whose character depends partly upon the situation, partly upon the nature of the exudation and the cause of the inflammation. As the description of the various clinical forms of inflammation is our aim, it must

be observed that combined forms occur very often, rendering the classification of special cases in a certain group difficult.

1. *Follicular Inflammation of the External Auditory Meatus (Otitis Externa Follicularis s. Circumscripta).*

Follicular inflammation of the external meatus has its seat chiefly in the cartilaginous section. The process commences either in a hair follicle or in a gland, but very often a whole group of neighbouring follicles and glands is affected. The inflammation is seated either in the deeper parts of the cutis lying near the perichondrium or in the superficial layers of the same.

Etiology.—Follicular inflammation, commonly called furunculosis of the auditory meatus, occurs often without any known cause in healthy, strong persons; sometimes it is a part of general furunculosis of the external integument. Intercurrent furuncular formations are observed in the course of chronic purulent otitis media and chronic eczema of the external meatus. Other causative conditions are: mechanical irritation of the meatus, especially frequent syringing; scratching with hard instruments in pruritus of the external meatus; injuries of the same; irritation caused by foreign bodies; instillation of irritating substances into the ear; the prolonged use of alum solutions (v. Tröltsch, Hagen).

Löwenberg found in furuncular pus not exposed to the air, masses of micro-organisms, which he looked upon as the cause of the furunculosis. The excitant of the disease has been proved to be the Staphylococcus pyogenes aureus and albus, which penetrate the hair follicles (Schimmelbusch). If the pus is discharged into the meatus, multiple furuncles may arise from the wandering of micrococci into other follicles, as is confirmed by the rapid recurrence of furuncles in the meatus.

Occurrence.—Furunculosis of the auditory meatus occurs especially in spring and autumn, so often that one is inclined to look upon the affection as epidemic in character. It occurs oftener in adults than in children; it is often observed in anæmia, in disorders of menstruation, in diabetes mellitus, and at the change of life (Hagen).

Symptoms.—The symptoms vary according as the inflammation is situated in the neighbourhood of the perichondrium, or in the superficial layers of the cutis. The affection begins, particularly when it is deeply situated, with gradually increasing, tearing or beating pains, which radiate towards various parts of the head and neck, till the height of the inflammation is reached, when the patient is robbed of his sleep. By touching the ear, but especially

by movement of the jaw, the pain is increased. The occurrence of fever and loss of appetite are not uncommon in the first few days. A feeling of fulness, subjective noises and disturbances of hearing occur, as a rule, only when the lumen of the meatus becomes blocked by a furuncle, very exceptionally when the meatus is free, and then it is in consequence of hyperæmia spreading to the middle and internal ear.

When the inflammation is deep-seated, the tumour due to the exudation appears flat, without sharp outlines, and only slightly red. When the site is superficial, on the other hand, the prominence is very red, livid, and sharply-defined, and generally develops without much pain, sometimes without any. The seat of the inflammation is most frequently the anterior inferior wall of the meatus. Often the furuncles are multiple, arising simultaneously or rapidly succeeding each other, so that by mutual contact they close up the lumen of the meatus. When they form on the anterior wall of the auditory meatus, the region in front of the tragus appears swollen and of a bluish-red colour, and when they are seated on the posterior wall there is sometimes so much swelling over the mastoid process that it might be mistaken for periostitis mastoidea. I once saw a fluctuating abscess on the mastoid process following a furuncle of the meatus, which emptied upon incising the furuncle in the meatus, and after applying a pressure bandage healed in a few days. Coincident glandular swellings on the side of the neck are on the whole rare. Follicular abscesses in the inner portion of the cartilaginous, and at the beginning of the bony meatus, appear mostly as yellowish-green pustules, about the size of hemp or millet seed, on the posterior and superior wall of the meatus.

Course.—The exudation thrown out in the neighbourhood of the follicle in most cases after the inflammation has lasted for four or five days, breaks down into pus. It is seldom that the abscess does not form before eight or ten days. Bursting usually takes place at the yellowish acuminate prominence at the highest part of the tumour, rarely at the side. The deeper the seat of the exudation, the more delay is there in the discharge of the abscess into the meatus. The inflammation seldom subsides without the formation of an abscess.

After the spontaneous or artificial opening of the abscess, the violent pain, as a rule, disappears, and gradually also all the other symptoms. Sometimes, however, violent exacerbations occur, in consequence either of recurrences at other parts, or of plugging of the opening of the abscess and obstruction to the escape of the pus from its cavity.

After the abscess has discharged, the tumour subsides in a short time; yet there often remains a slight infiltration and elevation on the affected part for some weeks. Spongy granulation tissue often projects from the orifice of the abscess-cavity, and may be mistaken for a fungiform polypus on the wall of the meatus. The course is always protracted by such growths, and cure is effected only after they have been removed.

Furunculosis of the auditory meatus tends to relapse. They appear either spontaneously or following repeated mechanical irritation, sometimes at shorter, sometimes at longer intervals (habitual furunculosis), and often cause emaciation and nervous excitement.

Diagnosis.—Having regard to the subjective and objective symptoms, this presents no difficulties. On a superficial examination exostoses in the external meatus, covered with reddened cutis, and those bulgings of the wall of the meatus which develop in the course of inflammation of the mastoid process, might be confounded with furuncles. The formation, sometimes with great pain, of single or multiple pustules in those parts of the osseous section of the auditory meatus in which the glandular elements are wanting, does not belong to the category of follicular inflammations.

Treatment.—In the stage of exudation the chief end of treatment is to allay the pain and get rid of it as soon as possible. In very painful, deep-seated inflammations it is best to make an incision in the tumour with or without local anæsthesia (Löwenberg), whether suppuration has commenced or not. In the latter case a bloody liquid will be discharged through the incision, and the pain will be alleviated by the relaxation of the cutis. When the pus is not reached by the incision it very soon makes a way for itself into the opening. The incision, which is performed with a small, blunt bistoury, is also recommended when the pus has reached the surface of the cutis, and the tumour is pointing at one place, but has not burst on account of the resistance of the dermic layer. Even in those cases in which an opening has already formed on the surface, which, on account of its smallness or in consequence of being plugged by a furuncle, is insufficient for the discharge of the pus, it is often necessary to extend the opening. After spontaneous or operative opening of the abscess it is advisable to exert moderate pressure on the external surface of the cartilaginous meatus, in order to bring the pus and the furuncular plug from the deeper parts to the surface.

Besides incision, other remedies may be used to allay pain; narcotic embrocations round the ear (*v.* Treatment of Acute Middle

Ear, *Inf.*); little plugs of wadding dipped in a mixture of aq. opii 4·0, aq. dest. 12·0, or a 5 per cent. solution of cocaine, and put into the auditory meatus; the introduction of a longish piece of lard covered with morphia and boracic ointment (boracic acid 1·0, vaseline 20·0, acet. morph. 0·2) into the auditory meatus; and the application of a warm raisin boiled in milk (popular remedy). These remedies are particularly recommended in the case of those who are afraid of operations. Leeches are rarely used; they are only necessary when incision does not allay the pain. Warm poultices allay the pain in some cases, while they increase it in others. On the other hand, I have recently seen rapid relief follow the application of Leiter's cooling apparatus (*v.* Treatment of Inflammation of the Mastoid Process). According to Rohrer, in many cases carefully carried out hydropathic fomentations produce rapid easing. Syringing the ear is to be avoided, as it may give rise to fresh eruptions.

The introduction of antiseptic treatment has made considerable improvement in the therapeutics of furunculosis of the external meatus. While with the earlier methods of treatment multiple furuncles were more frequent, and there were no known remedies for the prevention of fresh eruptions, it was observed that with antiseptic treatment new eruptions and relapses were less frequent. The most effectual remedies are carbolic acid as carbolic glycerine (0·5 in 15·0) applied with a brush, or dropped on cotton and placed in the meatus, boracic acid as a powder (Morpurgo) or as an alcoholic solution in the proportions of 1 in 20 (Löwenberg), further, the argilla acet. Burowi and the aluminium acetico-tartaricum (Hartmann), as instillation or by soaking cotton in the solution and applying in the meatus. All these remedies may be used before and after the opening of the abscess. I have seen the furuncles, after repeated painting with carbol-glycerine, recede without bursting into the meatus. When they recur repeatedly, one can use the stronger antiseptic solutions by instilling sublimate alcohol (Hyd. bichlor. 0·05—0·1, Spirit. vin. rectf. 50·0, Kirschner). This method is preferable to that proposed by Wilde, of cauterizing with silver nitrate, and that of Weber-Liel and Bendelak-Hewetson, to inject 2-5 drops of a 5 per cent. carbolic solution into the furuncle, which is very painful. Novarro (Milan, Congressber., 1880) has seen good results from cauterizing with the subchloride of zinc.

After the furuncle has been cut, the incision should be immediately anointed with carbolic glycerine or solution of boracic acid, to act on the micrococci and to prevent the bacteria from wandering into the neighbouring follicles; and it is advisable to continue the instillation of the argilla acet., sublimate, or boracic solution till the

incision is cicatrized. Cholewa and Szenes recommend the introduction of menthol; Rohrer the instillation of hydrogen peroxide. In chronic furunculosis of the meatus, Schwartz uses lukewarm ear-baths with a 1 per cent. solution of potassium sulph. when the inflammation has subsided.

After-Treatment.—After the follicular inflammation has terminated, the ceruminal secretion either ceases altogether or is of a crumbling, scaly nature. This abnormal secretion is usually accompanied with a troublesome itching, which causes the patient to scratch the meatus with all sorts of hard bodies. Such mechanical irritation is frequently the cause of relapses. The patient must therefore be strictly forbidden to scratch the meatus.

To prevent this troublesome itching, it is recommended that the cartilaginous meatus should be anointed every second day for several weeks after the disappearance of the furuncle with a precipitate ointment (hydr. præcip. alb. 0·3, ungu. emoll. or vaseline 12·0), or with boracic ointment (1 to 20 vaseline or lanoline), to which a little oleate of cocaine (5 per cent. of the basis) is added. The ointment must be sparingly applied, as by the introduction of large quantities the meatus would become blocked up in a very short time. I have also found painting with alcohol, as recommended by Weber-Liel, useful in several cases. Frequent wetting of the meatus with water, as in washing, is quite as injurious as in the case of eczema.

2. *Diffuse Inflammation of the External Auditory Meatus (Otitis Externa Diffusa).*

Diffuse inflammation of the external auditory meatus is very rare as an idiopathic affection, and the pathogenic microbes which find their way into the meatus from externally take an important part. It is more frequently due to the instillation or injection of irritating substances, or to mechanical and traumatic causes. Hessler (*A. f. O.*, vol. xxvi.) observed after injuries, infectious inflammation of a phlegmonus character. I cannot confirm the assertion that this affection occurs most frequently in children. I have repeatedly convinced myself that this diagnosis is often made in children in cases of acute purulent otitis media, the mistake arising from the fact that examination with the speculum is impossible; although this form often shows a desquamative character, the occurrence of a pustular inflammation of the external meatus is without doubt.

Symptoms.—The symptoms of otitis externa are specially marked in the osseous section and on the external surface of the membrana

tympani. The inflammation begins with great hyperæmia and painful swelling of the cutis, followed in a few days by a serous or viscid exudation. More than once I have observed the formation of a solid, transparent, gelatinous plug of exudate, especially during the influenza epidemic. On examination the contracted meatus and the external surface of the membrana tympani are found covered with a white layer of epidermis, which on syringing peels off, retaining the pouch-like form of the canal. In several cases upon microscopical examination I found such plates of epidermis containing large numbers of micrococci, which speaks for the mycotic nature of the affection. After the removal of this pouch the cutis and membrana tympani appear red and swollen, parts of the malleus are not visible, and the boundary between the membrana tympani and the auditory meatus is obliterated. Sometimes the meatus is so contracted by diffuse swelling or simultaneous follicular inflammation in its cartilaginous section that it is impossible to get a view of the deeper parts.

The subjective symptoms of otitis externa are violent radiating pains, increased by pressure near the ear and by the movements of the jaw; sometimes there are also subjective noises and giddiness.

The function of hearing is normal or but slightly impaired. It is only when the cutis of the membrana tympani is greatly swollen, or when there is an accumulation of exudation and epidermic plates in front of the membrane, and in cases of secondary swellings in the middle ear, that there is great difficulty of hearing.

In some cases I observed a group of symptoms deviating from those described; the inflammation developed with very slight reactive phenomena, but with rapidly increasing deafness and tinnitus. On examination, the meatus was found filled with an epidermic plug reaching to the membrane; after its removal the noises and deafness disappeared. The lining membrane of the meatus and the membrana tympani were moderately swollen and reddened, and covered with a thin layer of pus. Examination of the plug with the microscope revealed masses of micrococci in and on the cells. Whether these are the cause of the disease in such cases or are developed after exudation, has not yet been ascertained.

Course and Result.—In some cases the acme of the disease is reached on the third day, in others the course is irregular, the symptoms of resolution being followed by repeated exacerbations, with increased exudation and desquamation of epidermic plates. Therefore a cessation of the inflammatory phenomena can be looked upon as a sign of resolution only when the secretion ceases and the meatus becomes dry.

The result of this form of inflammation is generally recovery, with

complete restoration of the function of hearing; but subjective noises and deafness may remain long after the cessation of the inflammation of the meatus. The acute form sometimes, though not often, terminates in circumscribed ulceration on the membrana tympani, with perforation from without inwards, or in circumscribed ulceration on the inferior wall of the osseous meatus, with exposure of the bone and the growth of granulations in the area of the exposed parts. I observed once after the removal of a granulation which had arisen after four weeks' duration of the inflammation, the formation of an ulcer on the posterior superior wall of the meatus, which extended to the posterior half of the membrana tympani, and only healed up after being touched several times with powdered alum.

Transition into the chronic form is rare. It subsides generally without pain, often with great itching, and sometimes with subjective noises and deafness. The secretion is seldom so abundant that it runs out of the ear; it is usually of a thick, offensive, greasy nature, and contains, besides epidermis and pus-cells, many micrococci. After cleansing the meatus, the osseous section is found swollen, and often on its posterior superior wall, and sometimes on the dull membrana tympani, one or more granulations of the size of a hemp-seed are seen. Through apposition and adhesions such growths may form bands of tissue in the meatus (Engelmann, Bing). Sometimes in chronic inflammation of the osseous section a fibrous polypus, filling up the meatus, is developed, after the removal of which the membrana tympani appears intact. As a rule, one or two days after the extraction of such polypi, the secretion stops completely, and the hearing at the same time becomes quite normal. Occasionally a chronic desquamation of the ear remains.

Termination of the inflammation in hypertrophy of the cutis, in periostitis, and in hyperostosis with contraction of the meatus, in ulceration and extension of the suppuration to the parotid, and in caries, necrosis, and exfoliation of the flatter plates of bone in the wall of the meatus, without or with rupture towards the mastoid process, the cranial cavity, the sinus mastoideus, and the maxillary joint, is seldom met with in idiopathic, but chiefly in the traumatic, and in those secondary inflammations of the meatus arising in the course of chronic otitis media.

Diagnosis.—The diagnosis of primary otitis externa can only be made with certainty when the view of the walls of the meatus and of the membrana tympani is uninterrupted on every side, and when there is no suppuration in the middle ear. The diagnosis is more difficult when the meatus is much contracted, and when there is simultaneous follicular inflammation, as those conditions are very

often combined with diffuse swelling of the walls of the meatus. To complete the diagnosis the epidermic scales which have been cast off must be microscopically examined for micrococci and aspergillus fungus.

Prognosis.—The prognosis of idiopathic otitis externa is favourable, as not only do the acute forms subside without after-effects, but even those chronic cases in which granulations or large polypi have developed recover after their removal. Less favourable is the prognosis of traumatic inflammation and of those caused by corrosion of the walls of the meatus, which may produce stricture and atresia of the meatus, or with carious ulceration of the osseous walls, as the inflammation may spread to the cranial cavity or to the lateral sinus (Toynbee).

Treatment.—In acute inflammation, so long as the violent reactive symptoms last, the same palliative treatment is suitable as in acute otitis media. In the idiopathic form antiphlogistics (cold, local bleeding before the ear) are only to be used in the severer forms; in traumatic inflammations, on the other hand, cold applications, especially Leiter's apparatus, are recommended. With the commencement of secretion and shedding of the epidermic scales, local antiseptic treatment must begin. In acute cases it is almost always sufficient, after washing out the ear with a 2-3 per cent. solution of carbolic acid or with a weak solution of Lysol (2 per cent.), to insufflate finely-powdered boric acid, to stop the secretion. In chronic cases, where the swelling is not severe and no formation of granulations in the meatus, boric acid may be tried first. If the effect is not good after a few days, it is better to wash out the meatus with antiseptic solution, and instil boracic alcohol (1 in 20), boracic glycerine (Cresswell, Baber), sublimate alcohol (0·05 in 50), or iodol-alcohol (1 in 20). In obstinate cases this method first proves effectual after several cauterizations with a concentrated solution of nitrate of silver (0·8 in 10·0). After using the medicine the ear should be stopped every time with carbolized cotton. Where ulcers exist, which, in spite of the antiseptic treatment, show no tendency to heal, they should be cauterized several times after anæsthetizing with powdered cocaine.*

There remains yet to describe that desquamative inflammation of the external meatus, which is generally chronic in its course and goes on to the formation of cholesteatomous masses in the meatus. To this belong the 'molluscous' tumours of Toynbee and the 'keratosis obturans' of Wreden (*A. f. A. u. O.*, vol. iii.). These cholesteatomas of the external meatus are

* For those inflammations of the auditory meatus complicated with the formation of granulations and polypi, see the section on Aural Polypi.

rarely the product of an acute otitis externa with exuberant desquamation, but more often follow a chronic desquamative process frequently without symptoms, which, as I have many times seen, may go on to atrophy of the cutis and absorption of the bony walls. In the post-mortem room I have seen and dissected a number of cases, mostly both-sided, in which the meatus in its whole extent to the membrana tympani, was filled with a whitish lustrous cholesteatoma, without any change in the cavum tympani. In the majority of the preparations the lumen of the meatus was much enlarged, and either the superior posterior wall was hollowed out or the anterior wall was thinned, broken through, and the ossification openings which were present increased in size. In two preparations the posterior wall of the meatus was abraded so as to form an opening into the mastoid cells. By carefully removing the cholesteatoma through thorough syringing of the ear, and instilling boracic alcohol (1 in 20), the return of the epidermal mass may be prevented.

3. *Otitis Externa Hæmorrhagica.*

This form is characterized by hæmorrhagic effusion in the osseous portion of the external auditory meatus, seldom in the cartilaginous portion, accompanied with more or less well-marked reactive symptoms (Bing). It occurs usually in young persons without any known cause—frequently seen with influenza—commencing with moderate pain, tinnitus, and slight deafness. Examination reveals one or more dark blue elongated swellings in the osseous meatus, situated on its inferior, more rarely on its posterior walls; these often extend to the inferior posterior segment of the membrana tympani on the one side, and on the other to the cartilaginous meatus, and by contracting the lumen of the meatus they interfere with the examination of the membrane. The condition in such cases is one of superficial inflammation of the cutis, the epidermis being raised to a great extent by the hæmorrhagic exudation. On being probed, the swelling feels soft and yielding, and may be perforated by very slight pressure, a blood-coloured fluid escaping. Schwartze has observed the formation of hæmorrhagic vesicles in the osseous meatus at the beginning of violent otitis media. In one case of Wagenhauser's there was delirium with hallucinations (*A. f. O.*, vol. xxi.).

The acme of this form of inflammation is, as a rule, reached on the third day. The hæmorrhagic vesicles may remain for several days after the disappearance of the reactive symptoms, their contents being discharged by rupture or absorbed. Very often after the disappearance of the vesicles, others appear on different parts of the meatus. This disease can only be confounded with the hæmorrhagic bullæ which are produced by rarefying the air in the external meatus (Rohrer), or with livid-coloured polypi.

The result of otitis externa hæmorrhagica is always recovery; the elevated epidermis of the meatus and of the membrane being cast off in large scales after eight to fourteen days, the diseased parts become covered with a delicate dry epidermic layer, and the hearing becomes normal.

Treatment consists in opening the vesicles by means of a probe, and the subsequent removal of their contents by the insertion of Bruns' cotton into the meatus. The latter is then filled with powdered boracic acid, and this application is repeated till the powder remains perfectly dry for twenty-four hours. As a rule the powder only requires to be used three or four times to check the secretion in the meatus and on the external surface of the membrana tympani.

4. *Croupous and Diphtheritic Inflammation of the External Auditory Meatus (Otitis Externa Crouposa et Diphtheritica).*

Croupous otitis externa is one of the rare forms of disease of the external meatus. Wilde (*l. c.*, pp. 231, 232) indicates its occurrence, for he sometimes found the meatus and the membrana tympani covered with a layer of lymph, similar to that which lines the trachea in croup. Gottstein observed in one case, along with a croupous exudation on the tonsils, a croupous membrane adhering to the posterior wall of the osseous portion of the meatus, after the removal of which the excoriated surface bled slightly. Attention was first drawn to this form of disease by Bezold's communications (*Virch. Arch.*, vol. lxx.). He saw eleven cases of this affection in the space of three years. These are included in the thirty cases reported by Steinhof (Inaugural dissertation, 1886). The exudation of fibrin is confined to the osseous section of the meatus and the external surface of the membrana tympani. It seldom occurs alone, but usually after an exhausted otitis media, or along with furunculosis of the meatus. The formation of fibrinous membranes takes place at intervals of from one to two days; they may be loosened from the underlying tissue by moderately strong injections, and appear as solid, firm casts of the osseous meatus and of the membrana tympani. According to Steinbrügge, the exudate consists of a fine network, which is filled with round cells, nuclei and epithelium. Guranowski (*M. f. O.*, 1888) isolated the bacillus of green pus from the membranes of the patient described by him.

This inflammation, which usually affects healthy people, is developed with moderate pain, which reaches its acme with the commencement of fibrinous exudation, and ends, as a rule, with the

casting off of the membrane. The exudation may be repeated several times, but almost always without any other complication; it ends in recovery with complete restoration of the hearing.

The *prognosis* of this form of inflammation is very favourable.

Treatment consists in the removal of the croupous membrane by means of injections, or with the forceps, and the subsequent insertion of boracic acid into the meatus.

Otitis externa diphtheritica, occasionally combined with diphtheria of the auricle, seldom appears primarily, but is usually a complication of scarlatinous diphtheria of the throat and of the middle ear. Primary diphtheria of the meatus is, according to the observations of Moos, Bezold, Wreden, and Kraussold, developed during an epidemic diphtheritis out of an already existing otitis externa on excoriated parts of the meatus.

In the primary as well as in the secondary forms of this affection, the walls of the meatus appear covered with a dirty grayish-white exudation, which cannot be removed either by injections or by the forceps. After the membrane has been forcibly loosened by the probe, the wall of the meatus appears excoriated, ulcerated, and bleeding. The slightest touch on the ulcerated parts is extremely painful. The meatus is sometimes so contracted that it is possible to get a view of the deeper parts only after necrosis and shedding of the membrane (Blau). The parts about the ear are red and swollen, as are also the lateral cervical and the lymphatic glands behind the ear. Inflammation, commencing with moderate secretion, is accompanied in the primary form with great pain, feeling of fulness, tinnitus, and deafness; that, on the other hand, associated with diphtheria of the middle ear runs its course, according to Wreden, Wendt, and Blau, almost without pain, and with anæsthesia of the region of the ear.

Diphtheritic inflammation of the meatus has an uncertain course. Sometimes the exudation is rapidly thrown off, but often it remains firm for a very long time, or there are repeated exudations either on the already affected or on other parts of the meatus. In a very interesting case of diphtheritis of the middle ear and of the meatus described by Blau, the affection extended to the auricle, on which deep cutaneous ulcers were formed.

Diphtheritic inflammation of the meatus terminates without any permanent changes when the seat of the exudation is superficial; on the other hand, when the affection is deep-seated, the ulcers on the cutis, persistent and easily made to bleed, heal by cicatrization, narrowing and adhesion of the meatus.

The *diagnosis* of diphtheria of the meatus can be made with

certainty only when the presence of the peculiar adherent diphtheritic membrane has been ascertained by examination, after the removal of which an ulcerated bleeding surface is exposed. The diagnosis is rendered more probable when there exists an epidemic of diphtheritis, and coincident suppuration of the middle ear, along with naso-pharyngeal diphtheritis. The white exudations seen in children, occurring in the course of acute scarlatinous suppuration of the middle ear, extending to the external orifice of the ear, and due to maceration of the epidermis, must not be confounded with diphtheritis of the meatus. They differ from the latter in being easily peeled off in large flakes.

The *prognosis* of primary diphtheria confined to the meatus is, on the whole, favourable. The prognosis of the forms complicated with pharyngeal and middle ear diphtheritis is unfavourable; for, on account of the simultaneous extensive destruction of the membrana tympani, the frequent exfoliation of the ossicles, the consecutive caries, and very often the addition of an affection of the labyrinth, the function of hearing is much impaired.

The *treatment* of otitis diphtheritica is antiseptic. In primary diphtheritis of the meatus it is advisable, according to Burckhardt-Merian, to fill the canal at times with lime-water, in order to favour the loosening and separation of the diphtheritic membrane. After the fluid has been left for fifteen or twenty minutes in the ear the meatus should be syringed with a weak solution of boracic acid, and then filled with finely-powdered boracic acid or iodoform powder. If the membrane is repeatedly formed again, the affected part should be touched with carbolic glycerine (1 in 15) or carbolic spirit (1 in 20), and in addition the meatus should be filled several times a day with an alcoholic solution of boracic acid (1 in 20), or with one per cent. salicyl.-alcohol or with sublimate alcohol (0·05 in 50·0). Mechanical removal of the diphtheritic membrane hastens the recovery just as little as cauterization with lunar caustic.

5. *Parasitic Inflammation of the External Auditory Meatus—Mycoses of the External Meatus*

(*Otomycosis* [*Virchow*], *Myringomycosis Aspergillina* [*Wreden*]).

Although single cases of fungus in the ear had already been observed by Mayer,* Pacini,† and Carl Cramer,‡ the attention of otologists was first drawn to parasitic otitis externa by a short communication of Schwartze's (*A. f. O.*, ii.),

* Müller's *Arch. f. Anat.*, etc., 1844.

† Firenze, 1851.

‡ *Vierteljahrschr. d. naturf. Ges. in Zürich*, 1859-60.

and particularly by a detailed work of Wreden's (*Monograph*, 1868). More recently the pathology of otomycosis has been greatly enriched by valuable contributions from Burnett, Blake, Cassells, Hassenstein, Hagen, Bezold, Steudener, Löwenberg, Wagenhäuser and Siebenmann.

The most common fungus in the ear belongs to the species Aspergillus niger, flavus and fumigatus. The following are much rarer: the Vesticillium Graphii (Trichothecium roseum), described by Steudener; a fungus with grass-green conidia (Otomyces Hageni), described by Hagen; the Aspergillus nidulans; and the Ascophora elegans of v. Tröltsch. The Mucor corymbifer (Lichtheim's), first observed in the meatus by Wagenhäuser; the Eurotinus malignum of Lindt and Siebenmann, the Mucor sextatus and Penicillium minimum.

An examination of a fungous mass removed from the ear gives the following result: there is a felt-like, mycelial structure, intermixed with cast-off

FIG. 84.—ASPERGILLUS NIGRICANS.

a, Mycelium covered with numerous fallen spores; *b*, Hypha; *c*, Sporangium, with ripe spores; *b'*, Hypha; *d*, Receptaculum; *e*, Sterigmata with spores.

epidermis, from which arise upright, cylindrical, rigid filaments, often furnished with septa (Hyphæ, Fig. 84, *b*, *b'*), which support the head of the fungus (sporangium or fruit-capsule, *c*). The latter consists of the central vesicular enlargement (receptaculum, *d*), the long radiating cells seated upon the latter (sterigmata, *e*), and the round conidia or spores growing on its free end.

The colour of the various forms of fungi depends upon that of the conidia. They are blackish-brown in A. nigricans, yellowish or greenish in A. flavescens and in A. glaucus, and grayish-black in A. fumigatus. According to Burnett (*Am. Journ. of Ot.*, 1879), the fructification-heads are smaller and narrower in A. glaucus than in A. nigricans. A. fumigatus possesses the smallest sporangium, and, according to Bezold, more rarely occasions inflammation in the ear than the other species. The Mucor corymbifer is distinguished by the clustered position of the sporangium bearers, the small colourless pear-shaped heads, the brownish twisted columellæ and the small colourless spores.

Etiology.—The fungous spores which reach the meatus from the atmosphere can, under favourable circumstances, germinate and increase very rapidly. According to Siebenmann, an abnormality of the secretions in the meatus (Eczema squam. and slight secretions in Otit. med. sup. chron.) forms the principal condition for the growth of the aspergillus in the ear. If the conditions for germination of the fungus are present, it can occur in the meatus easier, as it is here protected from all mechanical effect. According to Bezold, fungous growths are oftenest observed after the instillation of oily substances, which, like all fats (Löwenberg), form a very nutritive material for the development of fungi. Fungi are often developed in the ears of persons living in a damp, mouldy locality. One case of mine was observed in a young man employed in the manufacture of yeast. Very often the cause of otomycosis cannot be ascertained.

Occurrence.—Otomycosis running its course with reactive phenomena occurs usually in middle-aged people, and rarely in children and in old people; it is more common among the poor than among the rich. The frequent development of fungi in individuals affected with chronic catarrh of the middle ear, depends certainly upon the instillation of easily decomposing substances into the auditory meatus. In chronic suppuration of the middle ear fungous growths are often developed on moist scabs, especially during the use of chloride of iron, but without causing any inflammatory phenomena. Burnett and Bezold have observed the fungus extend into the tympanic cavity. In one of the preparations in my collections the mycelium can be seen penetrating the membrana tympani. Fungous growths have not been observed in cases of profuse suppuration of the middle ear.

Symptoms.—Fungous growths in the auditory meatus, even when extending over a great part of it and of the tympanic cavity, may exist without any symptoms, so long as the fungus has its seat in the epidermis. When, however, the vegetations penetrate into the rete Malpighii and come in contact with the living tissue, that peculiar form of inflammation known as otitis externa parasitica commences. In two cases of aspergillus without symptoms observed by me, after a slight abrasion of the meatus a severe mycotic inflammation occurred. According to Wreden, the inoculation experiments which he made in healthy meatuses remained without results.

The subjective phenomena of parasitic otitis externa are great itching and flying twinges, which increase to violent pains radiating towards the head and throat. In most cases tinnitus and deafness are superadded.

On examination of the meatus in cases of A. nigricans, the osseous section especially and the membrana tympani are found covered with a black-spotted or entirely black membrane having the appearance of being strewn with fine coal-dust. On syringing it is washed out in shreds of considerable thickness, on the surface of which the characteristic black spots (sporangia) are visible either with the naked eye or with a lens. The side of the membrane lying next to the wall of the meatus is of a whitish or dirty gray colour. According to Löwenberg, the epidermis permeated with mycelium may take the form of small cysts, on the inner surface of which the fungous growths are seated. In cases of A. flavesc., the surface of the epidermis invaded with mycelium appears covered with a yellowish mass of dust like the powder of lycopodium.

After removal of such membranes from the meatus, the lining membrane of its osseous section and the membrana tympani are found very red, swollen, and in great part devoid of the epidermic layer. Here and there, however, are seen solitary, irregular gray islands, on which after removal with the probe epidermic cells mixed with fungous spores are recognised. In a growth of the fungus without inflammation of the walls of the meatus one can see the black or yellowish clump of fungus spreading out over a portion of the osseous meatus, and the hyphæ and sporangii may be seen with the naked eye or by slight magnification.

Course and Termination.—The course of parasitic otitis externa depends upon the extent of the fungous growths and the time treatment commenced. When the affection is left to itself or treated by a physician who does not know its nature, the inflammation may continue for several weeks without in the least abating, and, as I have observed in several cases, may lead to perforation of the membrana tympani from without inwards. In many cases the inflammation ceases, notwithstanding the presence of fungous growths in the ear, only to reappear with renewed vigour at intervals of weeks or months. On examining such cases the meatus is very often found filled with fungous membranes closely packed.

Immediately after removal of the membrane in the inflammatory stage there is a decided diminution of the pain and of the subjective noises, speedily followed by cure on proper treatment being employed. When, however, after the removal of the fungous membrane no antiparasitic remedy is used, on the following day, the meatus is often found re-covered with a thick fungous membrane similar to what had been already removed, with continuance of the reactive symptoms. Such rapid recurrence may go

on till either the fungus becomes exhausted or treatment effects a cure.

Diagnosis.—The diagnosis of fungous growths in the meatus presents no difficulty when with decided symptoms of otitis externa the characteristic appearance of the meatus is found on examination with the speculum. Sometimes, however, blackish-brown epidermic plates are syringed out of the ear, on which the brown covering appears as dust, coal-dust, or vegetable *débris*, which might be mistaken for those fungous membranes. In doubtful cases, therefore, microscopic examination is indispensable before giving a diagnosis.

Prognosis.—The prognosis of otitis externa parasitica is in all respects favourable, as, by the use of parasiticides, a rapid cure is effected, and, even after perforation of the membrana tympani, cicatrization of the aperture speedily follows. The prognosis is not so favourable, however, when there is the possibility of a recurrence of the inflammation, particularly in persons who live in damp, mouldy localities, in which the cause of a renewed attack is always present. I have also seen frequent relapses in persons in the most favourable circumstances without apparent cause.

Treatment.—Of the numerous remedies recommended for the removal of fungous growths, rectified spirit, recommended by Hassenstein and Küchenmeister, has proved the best. It is used as follows: After the fungous membranes have been nearly all removed by syringing, the meatus is then filled by means of a warm spoon with rectified spirit, which is kept in the ear for at least a quarter of an hour. This procedure is, at first, to be repeated twice daily. As a rule, the spirit can be well borne. When it causes a burning feeling, it is advisable at first to dilute the spirit with distilled water, and gradually to employ concentrated spirit of wine. In protracted cases I have seen a rapid result from instillation of an alcoholic solution of sublimate (0·05-0·1 in 50·0).

The result of the treatment is so quick, that even after two days no sign of fungus is visible in the meatus. The lining membrane of the meatus and the membrana tympani appear covered with a fine dry epidermis; pain, tinnitus, and deafness disappear, and after three or four days' treatment the cure is almost complete.

In order to prevent relapses, I consider it well to advise the patient to continue the application of the spirit at longer intervals, but at least once every four weeks, throughout a whole year.

Besides alcohol, there are a number of other remedies for the destruction of fungi. Among the most effective of these are boracic

acid in powder or in spirituous solution (1 in 20), or mixed with an equal amount of oxide of zinc (Theobald); permanganate of potassium in 6·10 per cent. solution (v. Tröltsch, Schwartze, Hagen); carbolic acid free from creosote (3·0 in 100·0 oil or glycerine, Lucae); spirituous solution of tannin (50 per cent., Wreden); spirituous solution of salicylic acid (2 per cent., Bezold); chlorinated lime (0·07-0·15 in 35·0 aq. dest., Wreden); hyposulphite of soda (0·2 in 30·0, Blake, Burnett); and pyoktanin powder (Rohrer).

Pityriasis alba, described by Ladreit de Lacharrière (*Annal. des Mal de l'Oreilles*, etc., 1875), remains to be mentioned as a rare mycosis. It occurs along with pityriasis capitas at the age of from forty to fifty years. After removal of the scales, which microscopically show the characteristic fungous spores, the cutis of the meatus appears thickened and red. This mycosis is not to be confounded with seborrhœa of the meatus, in which there is also a formation of fatty scales. The treatment of P. alba consists in the extraction of the stiffest hairs, and in painting the lining membrane of the meatus with a 1 per cent. solution of corrosive sublimate.

Kirchner observed a transplantation of pityriasis versicolor from the breast and neck to the external meatus, where it produced a troublesome itching but no other disturbance. Lang saw the dermatomycosis favosa and circinata on the auricle. The first cannot well be mistaken; the latter, not alone, but combined with a similar affection of the neck, may be mistaken for an annular syphilide.

C. *Eczema of the External Ear.*

Eczema of the external ear occurs either as a primary affection or combined with eczema on other parts of the body. It is either acute or chronic.

Acute eczema attacks either the auricle or the external meatus, or extends over the whole of the external portion of the ear. It begins with great redness and swelling of the skin, which is soon followed by the formation of numerous thickly spread vesicles containing serous matter (Eczema vesiculosum). The eruption mostly occurs on the posterior surface of the auricle and on the lobule, the entire auricle seldom being affected. Vesicles are rarely visible in the auditory meatus on account of their early destruction.

After the bursting of the vesicles moist surfaces, denuded of epidermis, are found on the auricle and in the meatus, which become covered in a few days with light yellow crusts (Eczema crustosum), under which the exudation of a serous or viscid fluid continues.

Occasionally, when there is very severe inflammation, pustules filled with pus occur about the size of a bean, which form thick crusts on bursting, under which the pustular secretion still remains (Eczema impetiginosum). The serous secretion contains diplococci according to Rohrer, and the later pustular accumulations contain staphylococci and bacilli.

Etiology.—Acute eczema is developed primarily or combined with eczema of the face, either without any known cause, or in consequence of external sources of irritation, especially after cold baths, from the influence of heat (Eczema solare), warm fomentations, or the application of irritating drugs (chloroform, rancid fat and oils, mercurial ointments, mustard-poultices, etc.). Among those artificial forms is reckoned that circumscribed eczema on the upper surface of the crista helicis which occurs, usually symmetrically on both ears, in persons who sleep on hard pillows of horse-hair. Acute eczema often arises in the course of acute or chronic otorrhœa from the action of the irritating secretion, especially in children and in individuals whose skin is easily irritated. In general, a scrofulous dyscrasia and rachitis plays an important part in predisposition to the formation of eczema.

Symptoms.—Acute eczema begins with a feeling of heat, burning, and itching, followed, after the appearance of the vesicles, by great pain in the part affected. In the case of children, and more rarely in adults, the disease is accompanied by slight pyrexia, restlessness, and sleeplessness.

The function of hearing is normal in cases in which the eczema is limited to the auricle; in disease of the auditory meatus there occurs a mechanical disturbance of hearing combined with subjective noises caused by the swelling of its lining membrane, and by the desquamation and accumulation of epidermis, exudation, and crusts. Rarely a recent middle ear catarrh intercurs.

Course.—The course of acute eczema is in the majority of cases typical. In slight cases the vesicles dry up quickly after the second or third day, the epidermis then desquamates and recovery takes place. More frequently, after the vesicles have burst, there is an abundant discharge of clear secretion, which abates after several days, and the parts laid bare become covered with light or brownish-yellow crusts. In normal circumstances, when the exudation is at a standstill, a new epidermis forms beneath the crust, which, after the latter has peeled off, very soon assumes its natural appearance. Sometimes, however, the exudation of clear or purulent fluid beneath the crust continues for several weeks before the formation of a new epidermic layer.

Results.—Acute eczema generally ends in recovery, which sometimes takes place in a few days, but frequently not for some weeks. The eczema sometimes heals on one part of the auricle or meatus and breaks out on another. Repeated relapses, caused by the continuance of the cause, by general illness, or by extending eczema on other parts of the body, occasion deeper tissue-changes in the cutis and the transition of the acute into the chronic form.

On the line between acute and chronic eczema of the external ear is that subacute form eczema crustosum and impetiginosum which is seen in young children. The posterior surface of the auricle, the retro-auricular niche, the sulci and depressions of the concha are affected, associated with an extensive subacute eczema of the head and face, or from pediculosis capitis. This form of eczema manifests itself by a specially profuse production of crusts and scales, which are situated upon a very much congested and inflamed basis. The intense itching, the excessive feeling of heat, and intolerable tension cause the children to rub and scratch the ear, which produces pain and very often bleeding injuries to the posterior surface of the auricle. On the other hand, the resorption of the pus, which is confined under the adherent crusts, often produces extensive disease of the skin, accompanied by fever and inflammation and suppuration of the retro-auricular and cervical lymph glands. The treatment described generally succeeds in quickly palliating this very painful affection, and in preventing its change into the chronic form.

Chronic Eczema is distinguished from the acute form by the deeper tissue-changes in the cutis. While in acute eczema the inflammation is confined to the uppermost layer of the cutis, in chronic eczema there is hypertrophy of the subcutaneous connective tissue which leads to narrowing of the cartilaginous auditory meatus and condensation, enlargement, and rigidity of the auricle. The secretion and scabbing are localized in the depressions of the auricle and on the posterior part of its attachment, while there is abundant desquamation on the remaining parts.

Chronic eczema of the auricle and of the external meatus appears most frequently as crusty or scaly eczema. The two forms may be combined. The crusty form is characterized by the formation of thick scabs, under which a serous or purulent fluid is exuded. It presents, therefore, on the whole, the same phenomena as acute eczema in the scabbing stage.

The scaly form of eczema is characterized by hyperæmia and hypertrophy of the cutis combined with continued desquamation of the epidermis. The affection is often combined with eczema of the scalp, and is but rarely confined to the auricle or auditory meatus. Squamous eczema may arise out of the chronic moist form, but it occurs more frequently on the cutis as a scaly eczema without any

preceding serous exudation. In slight cases the desquamation is so trifling that it is confined to a few depressions of the auricle or to the parts surrounding the external orifice of the ear. In more severe forms, however, the eczema spreads not only over the auricle and its neighbourhood, but over the entire auditory meatus and the external surface of the membrana tympani. In this case the auricle is enlarged owing to the great infiltration of the cutis, and the meatus is narrowed; and in the depressions on the superior and posterior places of attachment of the auricle as well as on the superior periphery of the external orifice of the ear there are found ragged, slightly secreting fissures of the skin which are difficult to heal.

Symptoms.—Of the symptoms of chronic eczema a troublesome itching is the most constant, causing the patient to be continually scratching the meatus with some hard instrument, thereby setting up intercurrent painful inflammation in that canal. Subjective noises are induced either by plugging of the meatus with desquamated scales or by secondary hyperæmia in the middle ear and in the labyrinth. So, also, disturbances of the hearing may arise without mechanical obstruction in the auditory meatus from simultaneous swelling of the mucous membrane of the tympanic cavity and of the Eustachian tube.

Course and Termination.—The course and termination of chronic eczema vary according to the severity of the skin-affection. The slighter forms, confined to the ear alone, may recover spontaneously or disappear after short treatment, while the severe forms very rarely recede spontaneously, and prove very stubborn to treatment. Even when recovery is apparent, there is a relapse of the eczema sooner or later. Sometimes there are intercurrent painful follicular inflammations in the external meatus.

A rare result, although well known to dermatologists, of the chronic eczema, especially with formation of crusts, is the true elephantiatic thickening of the auricle, in pachydermia. Where there is a large increase of the connective tissue in the parts joining the skin, an extensive lymph stasis occurs in the network of the cutis, which produces a peculiar soft doughy feeling. Slight mechanical injuries serve in these cases of elephantiatic thickening of the skin to produce an eruption and are the source of frequent recrudescence of the eczema.

Diagnosis.—The diagnosis depends on the above-described objective signs. According to Auspitz it is possible to confound it with seborrhœa of the external ear, but in the latter there is an absence of redness and infiltration of the skin.

The *prognosis* of chronic eczema is favourable only as regards the recurrence of exudation or desquamation in its slighter forms; on the other hand, in severe cases, complicated with eczema of the

scalp, or other parts of the body, and combined with hypertrophy of the cutis, it is most unfavourable.

Treatment.—In the treatment of eczema of the ear, the causes and the stages of the skin-affection must be considered. Although acute eczema often heals spontaneously, it is necessary to avoid in the acute stage all injurious irritation which keeps up the exudation and impedes the growth of new epidermis. The patient must, therefore, be forbidden to wash the affected parts with water, or to syringe the ear, while he is to protect the inflamed parts of the skin, or those laid bare by the bursting of the vesicles, from the influence of the air by painting them with ungu. emolliens or vaseline. Moist surfaces on the auricle, especially intertrigo behind the ear, which occurs frequently in children, are best covered with powder, or with pulverized calomel. The latter is recommended by Rohrer as well for acute as the moist form of chronic eczema. The powder, however, is not suitable for acute eczema of the auditory meatus on account of the rapid obstruction of the canal. Cold compresses on the region of the ear, with the addition of liq. plumb. acet. or liq. Burowi (with 10 times the amount of water) in combination with pencilling, with a 5 per cent. sol. of cocaine, are indicated only in extensive and painful eruptions in the stage of vesication. Ichthyol, which has been lately recommended, has proved useful in many cases, either in substance or in aqueous and alcoholic solutions (1·0 in 50·0), and in the form of an ointment (1 in 60).

When a patient presents himself for treatment at the scabbing stage, the crusts must first be removed, in order, if possible, to render remedies effectual on the diseased cutis. Forcible loosening of closely adherent scabs or the rubbing of them off by means of dry linen cloths I consider injurious, because I have observed the formation afterwards of new and thicker scabs, notwithstanding the use of the most effective remedies. The crusts are best softened by the application of vaseline, sweet oil, or of balsam of Peru, and may be removed on the following day with a brush or forceps.

A very valuable method, on account of its peculiar property of quickly macerating and loosening the adherent crusts, is the application to the diseased part of liquor Burowi in the above-mentioned strength. It is necessary to carefully apply several layers of the cloth used for the fomentation, and cover with some waterproof material (gutta-percha cloth—Billroth cloth) to prevent evaporation. If the compresses are changed every 2 hours, at the end of 24 to 48 hours the crusts are softened, so that they may be removed with a pincette without hurting the patient, after which it should be dressed with ointment.

Then, without irritating the exposed parts further, the auricle, with all its depressions, is painted with a medicated ointment. For this purpose the following are the best: Hebra's diachylon ointment (prepared with olive oil): ungu. plumbi carbonatis and ungu. emolliens, āā. part. æqual.; ungu. vaselin. plumb. (empl. diachyl. s. vaselin. pur. āā. part. æqual.); ungu. acid. boraci. (1 in 15 vasel.); ungu. oxid. zinc. (1 in 30); Lassar's paste (zinci oxyd., amyl. orizæ. āā. 10, vaselin. 20·0); Pagenstecher's ointment (Hedinger). In addition, both auricles are covered with fine linen spread with the ointment. To produce complete contact, the cloth is pressed into the depressions of the auricle, and particularly during the night by putting on a wadding compress fixed by a light bandage. Small pledgets, corresponding to the width of the auditory meatus, and impregnated with the ointment, are pushed into the meatus. Those as well as the dressing on the auricle must be changed every twenty-four hours, and the ointment mixed with exudation should not be washed, but carefully brushed off. The salicylic soap plaster (acid. salic. 1 to empl. sapon. 10) introduced into dermatology by Pick has proved very useful in the treatment of eczema of the auricle with crusts, impetigo, and scales. This is also true of the Beiersdorf-Unna mull, treated with ointment (zinc, bor. and salicylic acid), and the recently recommended medicated tragant-gelatine, especially the zinc and boric acid gelatine. The latter is used in a 5 to 10 per cent. mixture once or twice a day. The medicated gelatine, without warming, is painted upon the diseased part of the auricle, where it hardens and forms a protective covering for the diseased portion. The pencilling with 1 to 3 per cent. solution of silver nitrate in eczema with crusts is useful only in obstinate cases.

After the crust is removed, the newly-formed epidermis is tender and little resistant, and the cutis remains for a long time hyperæmic. All irritation, therefore, which might destroy the epithelium and increase the hyperæmia of the cutis, must be avoided; frequent washing and rubbing of the skin must be discontinued, as well as syringing of the auditory meatus, and for several weeks these parts of the skin should be anointed with a thin layer of vaseline, cold cream, or a weak precipitate ointment (0·2 in 15).

Chas. Delstanche has observed very favourable and rapid healing after the treatment as used by Delstanche, senr. This consists in syringing out the meatus with a lukewarm saturated solution of plumb. acet., and the diseased portions on the auricle are soaked with the same. After this the surface of the eczematous places are rubbed with a piece of fine linen to remove the crusts, and then the auricle is massaged between the fingers to soften it and reduce the interstitial infiltration. To finish, the diseased portions are again

washed in lead solution by means of the syringe. Between the treatments the eczematous spots remain uncovered.

The treatment of squamous eczema is regulated by the intensity of the desquamation and the amount of the infiltration of the skin. In its slighter forms on the auricle, repeated painting with tinct. rusci, carbolic spirit (1 in 30), an alcoholic solution of boracic acid (1 in 20), or frequent cleansing with tar or soft soap (Auspitz), often suffice to effect a cure. More severe forms with great thickening of the epidermis and infiltration of the cutis, on the other hand, prove very obstinate. If the epidermis is much thickened and indurated, it must be softened by the daily application of a 10 to 15 per cent. salicylic soap plaster, or the fomentation with Liq. Burowi. It is necessary to wash more obstinate parts with a solution of potash soap in spirit, in order to remove the indurated epithelium. The use of mull saturated with gutta-percha plaster, alone or salicylated, as recommended by Unna, has proved very efficacious, as it can be adapted to the form of the auricle, and adheres very tenaciously, besides macerating and loosening the scales. Sometimes this method alone is sufficient to heal a chronic scaly eczema, at least after using this treatment for one or two weeks there is a marked lessening of the rigidity and tendency to laceration of the skin, and a healing of the fissures and clefts on the auricle. If after this time the skin is not entirely smooth, tar may be used. The first proceeding consists in rubbing ol. rusci into the reddened parts by means of a stiff pencil, and this is repeated till the brown tarry scurf has been rubbed off. When the skin has become smoother, more flexible, and paler by this repeated painting with tar, it is time to employ the tar ointment (ol. fagi 10·0, glycerine 5·0, ungu. emolliens 40·0), painting with ol. cadini and glycerine (1 in 25), sulphur ointment (flor. sulph., ol. cadini, styrac. liq. āā. 10·0, ungu. diachyl. s. ol. amygdal. āā. 15·0), ichthyol ointment (1 in 10 lanoline), carbolic ointment (1 in 40), white or yellow precipitate ointment, ungu. Wilsoni (benzoic acid 5·0, ungu. commun. 150·0; strain and add oxid. zinci 25·0). Of these remedies, sometimes the one and sometimes the other is effectual, according to the case.

Amongst all the remedies for squamous eczema in the external auditory meatus, painting with concentrated solutions of lunar caustic is the most effectual. After the scales have been removed from the walls of the meatus by means of a dry pellet of cotton-wool, the solution is applied to them with a brush or a ball of cotton-wool. The scurf falls off in one or two days in the form of blackish-brown dry plates, leaving the cutis smooth and paler in colour. In slight cases, the cutis resumes its normal appearance after having been

cauterized two or three times. In more severe cases, combined with great narrowing of the cartilaginous meatus, cauterizing requires to be more frequently repeated (8 to 10 times), in order to allay the swelling of the cutis. Fissures at the external opening of the ear should be treated first with Lassar's paste or with salicylic soap plaster, and if they show no tendency to heal under this treatment they should be touched with solid caustic.

After the caustic treatment it is necessary, in order to prevent relapses, to anoint the cutis of the cartilaginous meatus twice a week with a thin layer of white precipitate ointment, or with a weak ointment of ol. cadini (1 in 40 vaseline), and to continue it for some time. By that means the troublesome itching is most surely subdued.

With the healing of the eczema, the disturbance of hearing and subjective noises which accompany it frequently disappear, but not always.

Internal treatment of aural eczema is almost superfluous. In anæmic and scrofulous persons, especially children, the course of a chronic eczema will be shortened by the internal use of cod-liver oil, iron preparation, iodide of iron, arsenic (Fowler's sol. 3 to 10 drops per day, with tinct. malat. ferri), or the waters containing arsenic, Roncegno, Levico, etc.

Among the rarer affections of the skin of the external ear are reckoned pemphigus, herpes zoster, lupus, and psoriasis.

D. *Herpes Zoster.*

This affection is characterized by the painful development of transparent vesicles grouped together on a reddened surface. The site is either the posterior surface of the auricle, particularly the lobe, or the region in front of the tragus, and the anterior superior wall of the meatus, according as the herpes is caused by an affection of the trigeminus (anterior surface), or of the great auricular nerve (posterior surface), or the ganglion belonging to these nerves. Hartmann saw a herpes eruption on the membrana tympani. The formation of these vesicles is preceded by violent and rarely remitting pains in the head and in the neighbourhood of the ear, which continue for several days. After the eruption appears, accompanied sometimes by fever, the pain generally subsides, but it may also continue till the vesicles dry up. Occasionally a paralysis of the facial nerve occurs on the affected side, as I have observed in a few cases, at the time of the eruption, and recovered in a few weeks after healing of the herpes. Neuralgia, which usually remains after the termination of zoster

along the intercostal nerves, I have only seen in one case, in which it disappeared some weeks after recovery of the herpes.

The termination is recovery, as after bursting of the vesicles the diseased parts become covered with a crust, which falls off on the formation of a new epidermis.

Treatment consists in combating the violent pain by applying a 5 per cent. cocaine ointment, and by the internal exhibition of

FIG. 85.—HERPES ZOSTER OF THE AURICLE IN A CHILD OF 9 YEARS, AS OBSERVED BY DR. HERMET IN PARIS.

quinine, antipyrine, or a narcotic, and when that is ineffectual, by a subcutaneous injection of morphia. After the vesicles break, their drying up is effected by sprinkling them with powder or anointing them with unguent. plumb. acet. or plumb. carbonatis.

E. *Lupus.*

Lupus vulgaris of the auricle is often seen accompanying extensive lupus of the skin of the face. Its occurrence alone limited to the auricle is more rare. All known forms of lupus—L. maculosus, exulcerans, hypertrophicus, papillaris, and framboïsoides—occur on the auricle according to which form it manifests on the skin of other portions of the body. There occurs here, as in other parts of the body, changes from one form to another. Generally one finds disseminated plaques of lupus maculosus on the lobule, in the depression of the concha, or on the posterior surface of the auricle. It appears in the form of brown tubercles the size of a pin-head or lentil, covered with scales thickly grouped together, and penetrating

deep into the subcutaneous tissue. They seldom ulcerate, but by their shrinking produce cicatrices in the skin. By the smaller size of the efflorescence, the moderate amount of scales formed and the characteristic shrinking so as to form hard, hypertrophied, and even keloid scars, it is distinguished from psoriasis, which occurs on the ear only, combined with extensive psoriasis of the skin on other portions of the body.

Lupus exulcerans of the skin of the cheek often attacks the anterior surface of the auricle, and forms here ulcers of different sizes, covered with thick crusts, after the removal of which the base presents a spongy, glandular appearance. The edge of the ulcer is often livid and undermined. It is often possible to find in the edge of the ulcer typical lupus nodules springing from the cuticular tissue, and not yet ulcerated. The finding of these makes the diagnosis of lupus certain.

The lupus of the auricle gives a very peculiar impression according to Neisser, when the lobule is simultaneously affected, as it hangs down from the auricle as a large pear-shaped tumour, and ulcerates later than the other portions. Cases of lupus exulcerans limited to the auricle appear to have been rarely seen. One case in my practice affected an otherwise healthy young man, belonging to the better class, and had existed for several months limited to the auricle. The lupous ulceration appeared on the upper half of the auricle and extended round to its posterior surface. On individual parts of the anterior surface, the skin was so completely destroyed that the cartilage of the ear, suffused with blood, was quite exposed. The sharply defined edges of the skin appeared spongy, soft, and bled easily. By the repeated application of the sharp spoon and cauterization with solid argentic nitrate, a cure was effected after some weeks' treatment, leaving, however, cicatrization and slight deformity of the auricle. In a second case (a girl of 25 years), in which the lupous infiltration took place from the lower part of the lobule upwards, towards the posterior edge of the auricle, after several months' energetic cauterization with solid nitrate of silver, it was made to heal without leaving any deformity.

The lupus hypertrophicus (tumidus, papillaris, framboïsoides) may grow from the floor of the exulcerated lupus vulgaris, if it is neglected and not properly treated. While the lupous destruction of skin tissue progresses by the continual deposit of lupus nodules in the deeper parts of the cutis, the excessively developed granulation tissue upon the floor of the ulcer, in the form of glandular and papillary growths, gives a deformed appearance to the affected auricle. Often the granulations are of a spongy character, bleeding easily; but only

seldom do they become hard on their surface, while the ulceration continues at their base. These forms of lupus are the most malignant and obstinate, as they produce the most extensive destruction of the auricle. In especially protracted cases it goes on to inflammation, ulceration, necrosis, and finally to a deformed contraction of the whole cartilage of the ear, or more or less of the auricle is totally destroyed (lupus mutilans).

Only rarely the localized lupus of the pharynx extends along the tube to the middle and inner ear. Gradenigo has described such a case in which it progressed to lupous destruction of the membrana tympani, the ossicula, the mucous membrane of the cavum tympani, and the vestibule.

The *treatment* of lupus vulgaris has in view: 1. The removal or destruction of the lupus granulations; 2. To guard against deformity. In the ordinary non-ulcerative lupus the two objects will be most easily obtained if only the true lupus nodules are destroyed by cauterization and not the whole surface containing them. This is best performed by pressing a pointed piece of lunar caustic into the nodules which are visible, as it easily penetrates the soft, rotten tissue. This procedure is to be repeated until no recurrence of either nodules or spots takes place. The consecutive cicatrization is relatively small by this treatment, and the healthy skin between the spots of infiltration are left intact. The same result is also obtained by Hebra's cauterization with caustic potash and silver. After well cocainizing the diseased portion, a 30 per cent. solution of caustic potash is freely applied until the skin covering this portion is removed. The surface is now quickly painted with a 25 per cent. solution of nitrate of silver, which is prevented from running over the healthy portion by means of moist cotton. The solution then penetrates into the depth of the lupous infiltration, which it destroys without injuring the healthy skin. It is better to cover the wounded part with iodoform gauze for antiseptic reasons. Acetic acid, which was recommended by Mosetig-Moorhof on account of its peculiarly destructive action on diseased tissue, and not affecting the healthy tissue, may also be used in lupus of the auricle. Pencilling with iodine-glycerine (1 in 2) and concentrated carbolic acid are of subordinate value. Better results in protecting the skin may be obtained by using pyrogallic acid, which is applied in the form of a 20 per cent. ointment several times during the 24 hours.

In all forms of lupus exulcerans the ulcerating surface should first be thoroughly cauterized to remove the granulation growth. Spongy and hypertrophied granulation growths must be removed with Volkmann's spoon, after which the base of the lupus should be cauterized

with either solid argentic nitrate, or the galvanic or thermo-cautery. By continued use of these methods of cauterization all the diseased tissue may be destroyed and the progress of the disease stopped, although it sometimes requires several months. Even if the formation of cicatricial tissue is considerable, and generally there is considerable deformity remaining after the lupus exulcerans has healed, the energetically used cautery is the only effective means by which not only healing is brought about, but also the more extensive deformity of the auricle is avoided.

Lupus erythematosus occurs on the free edge of the auricle and on its posterior surface, accompanying lupus erythematosus of the face. It progresses without ulceration to cicatricial atrophy of the cutis. In its general extensive form, known as erysipelas perstans, the auricle is always simultaneously affected. The ordinary chronic form of lupus erythematosus is treated with applications of soft soap, painting with iodine-glycerine (M. Richter) or by scarification, followed by cauterizing with chloride of zinc (Veiel).

F. *Syphilitic Inflammation of the External Ear.*

Primary syphilitic affections in the region of the external ear are very rare. In Lang's lectures on 'Pathology and Treatment of Syphilis,' p. 430 (Wiesbaden, 1885), are cited two cases, one by C. Pellizzari,* the second by J. Zucker,† of which the location of one was on the lobule and the other on the anterior wall of the osseous meatus. In both cases the cause of infection was easily found. In the first case the infection followed the use of a handkerchief which had previously been used by the syphilitic son of the patient, the second case was produced by the too fervent love-caress of a publican. A third case of primary syphilitic infection on the auricle is reported by Hermet,‡ in a woman aged forty-two years, who acquired the chancre through the caress of her own husband who was infected. The report of a fourth case I owe to the friendly communication of Dr. Hermet, in Paris, who saw a phagedenic chancre sclerosis on the lobule and the under third of the auricle. The infection followed a bite on the auricle received in a fight with a syphilitic individual.

Secondary syphilitic affections of the auricle in the form of squamous, pustular, and papular eruptions occur only in general cutaneous syphilis, and especially when the skin of the forehead and the scalp are affected at the same time. Gummous syphilitic nodules are seldom met with, but according to an observation made by Burnett, they may spread over the entire auricle, and by the formation of deep-seated ulcers partially destroy it.

* *Virch. Arch.*, vol. lxix., p. 313.
† *Zeitschrift. f. Ohrenh.* vol. xiii., p. 171.
‡ *Annales de Dermatologie et de Syphilographie, 2ème Série, Extrait.*

Of the syphilitic affections occurring in the external meatus, condylomata and ulcers have been the most accurately studied.* Condylomata in the auditory meatus occur only in general syphilis, and often with condylomata at the same time on other parts of the body. They usually occur simultaneously with general symptoms of syphilis (Stöhr, *A. f. O.*, vol. v.); *i.e.*, with signs of syphilitic affections of the skin, pharyngeal ulcers, and glandular swellings. Occasionally confluent condylomata occur in both auditory meatuses (Noquet, *Revue mensuelle*, July, 1885).

The initial stage of condylomata as a rule escapes observation on account of the absence of striking symptoms. According to Knapp (*Z. f. O.*, vol. viii.), they commence with reddish, gradually-increasing efflorescences in the meatus, followed by diffuse swelling of its walls, with moderate secretion. On the secreting parts the condylomata spring up, more or less quickly, in the form of reddish or grayish-red, ragged, warty excrescences, which extend from the entrance of the ear to the osseous meatus, and render the lumen of the canal quite impermeable. In one of my cases the condylomata were limited to the parts of the cartilaginous section bounding the orifice of the ear. In another case the condylomatous growth could be followed nearly to the membrana tympani.

While the initial stage runs its course without symptoms, violent, radiating pains, increased by movement of the jaw, appear with the formation of the condylomata, and especially with their ulceration; only in occasional cases is there any fever (Stöhr). Subjective noises and deafness are caused either by mechanical obstruction of the auditory meatus or by consecutive affection of the middle ear, which, as in a case observed by Knapp, may be associated with bilateral perforation of the membrana tympani.

Condylomata of the auditory meatus either heal by resolution, which quickly follows on energetic general treatment and the suppression of the other syphilitic symptoms, or end in destruction of the efflorescences with profuse, fœtid secretion and the formation of unhealthy, confluent ulcers, seated usually on the inferior posterior wall, and healing very slowly. By rational local and general treatment, cure follows after some weeks or months, with or without cicatrization. In the latter case that portion of the meatus appears sunken and devoid of hairs. Stricture of the meatus seldom remains.

* Among 1,200 syphilitic patients, of whom 980 had condylomata, Desprès (*Ann. d. Mal. de l'Or.*, etc., 1878) observed condylomata in the external meatus five times. Buck (*Am. Journ. of Otol.*, 1879) among 4,000 persons with ear disease met with 30 cases of syphilis of the ear, 5 of which suffered from condylomata and ulcers. Ravogli (*Congressber. Mailand*, 1880) among 144 cases of syphilis found the middle ear affected fifteen times and the external meatus only once.

The diagnosis of condylomata in the auditory meatus, which can be confounded with granulations only on superficial observation, depends on the simultaneous existence of the characteristic symptoms of syphilis on the genitals, the skin, and the throat, and on the accompanying glandular swellings.

The prognosis of condylomata of the auditory meatus is favourable.

The papular syphilitic infiltration may occur on the external surface of the membrana tympani, as observed by Lang (*l. c.*, p. 431), who saw a large pale, glancing papule in the position of the short process of the malleus in a female with a recent general syphilis. The anterior superior quadrant of the membrane was greatly injected and the whole membrana tympani was opaque. Conversation could only be heard at the distance of five paces.

Gummous syphilitic ulcers seldom attack the external ear without a simultaneous affection of the middle ear. Alb. H. Buck (*Am. Journ. of Otol.*, 1879) records several cases of syphilitic ulceration on the auricle and in the meatus, with characteristic base and steep, elevated margins. The occurrence of nasal and pharyngeal syphilis, and the infiltration of the cervical glands at the same time were evidence of the specific nature of the affection. Hessler (*A. f. O.*, xx.) saw partial necrosis of the auricle following an ulcerating gumma. In a case communicated by Ravogli (*l. c.*) of a nodular syphilide on the side of the neck, several syphilitic nodules were developed in the meatus and on the membrana tympani, which formed angry, isolated ulcers with deep base and elevated margins. Baratoux observed a gummatous infiltration in the lower part of the left membrana tympani.

In a case observed by me, a characteristic ulcer formed on the inferior wall of the meatus in the course of chronic suppuration of the middle ear. The fatty base of the ulcer occupied the anterior and lateral walls of the cartilaginous portion, and its steep, elevated margins involved the external orifice of the ear. The simultaneous occurrence of pharyngeal syphilis left no doubt as to the syphilitic nature of the disease. In a second case there was, in addition to an ulcer occupying the whole length of the cartilaginous wall of the auditory meatus, a second round one with elevated edges in the concha.

Syphilitic inflammation of the throat is well known to transmit itself to the middle ear. Either catarrh occurs with impermeability of the Eustachian tube and accumulation of serum or mucus in the middle ear, or the ulceration extends to the cartilage of the tube, whereby a portion of it is destroyed, leading to subsequent contraction or adhesion of the tube. Moreover, simple as well as ulcerative

syphilitic inflammation of the pharyngeal cavity may lead to purulent otitis media with perforation of the membrana tympani; but examination with the aural speculum seldom reveals a condition differing from the common forms.

The treatment of condylomata of the auditory meatus consists, besides general treatment, in several (3-6) cauterizations of the granulations with lunar caustic or concentrated solutions of chromic acid, and, after reduction of the warty growths, in anointing them with corrosive sublimate solution (0·1 in 30·0), or tincture of iodine. Knapp recommends dusting the condylomata with calomel and afterwards painting with a 1 per cent. solution of nitrate of silver. In ulceration of the auditory meatus it is recommended to paint the ulcerated parts several times with tincture of iodine, and when the ulcer has lost its fatty appearance, to apply to it camphorated oil. In one case cicatrization was brought about by keeping a plug of mercurial plaster in the meatus.

III.—Diseases of the Perichondrium and Cartilage of the Auricle and External Meatus.

1. *Othæmatoma* (*Hæmatoma Auris*).

Othæmatomata arise from a sudden effusion of blood between the cartilage of the ear and the perichondrium, by which the latter, with or without destruction of its continuity, is extensively separated from the cartilage. As the cartilage of the ear is traversed by numerous vascular bands of connective tissue (Pareidt), it is probable that by violent pulling an othæmatomata with partial tearing of the cartilage may be occasioned by the rupture of these vessels (Haupt, *Dissers. inaug.*, Wurzburg, 1867).

Etiology.—Othæmatomata most frequently arise from injury, seldom spontaneously. In a case described by Brunner (*A. f. O.*, vol. v.), the cause was ascribed to long contact of the auricle with a cold pane of glass. The fact that often after violent pulling the auricle remains intact, while at other times a slight pull suffices to give rise to an escape of blood, renders it probable that certain tissue-changes in the cartilage, especially in old and tubercular individuals, are the predisposing cause of the othæmatoma. As such are given by L. Meyer, Pareidt, Haupt, Leubuscher, Simon, Virchow, and J. Pollak, the following degenerations of the cartilage of the ear: softening and fissure, the formation of cavities with gelatinous homogeneous contents, proliferation of vessels and new formations. In one case

of left-sided othæmatoma I found on the right ear, corresponding to the affected portion on the other side, an opaque thickening of the cartilage, 4-5 mm. in size, which led one to conclude there was a symmetrical tissue-change predisposing to othæmatoma. It might be imagined that repeated injuries could give rise to such changes in the cartilage, that at last a little violence would cause an effusion of blood.

Among the twenty-seven cases observed by Brigade-surgeon R. Chimani in the course of fourteen years, twenty-one were traumatic and six spontaneous in origin. In nineteen cases of the first category, in which the cause was positively ascertained, the othæmatoma in the left auricle was due nine times to a box on the ear, twice to a blow with the fist, once to pulling, and once to a blow with a bayonet-sheath; in the right ear, twice to a box on the ear, three times to blows, and once (complicated with rupture of the membrana tympani) to plunging into water from a considerable height. In the two remaining cases of othæmatoma of the left auricle, it was doubtful whether they had been caused by a box on the ear or otherwise.

Of the six spontaneous othæmatomata, four were on the left, and two on the right auricle. Of the individuals between twenty-one and twenty-six years of age, five were perfectly healthy, and only one debilitated by the cachexia of intermittent fever. Twenty-one cases were dismissed cured; in five the auricle was more or less deformed, and in one the cartilage of the ear was for the most part lost by ulceration.

Occurrence.—Othæmatomata occur in healthy individuals, remarkably often, however, in imbeciles. The left auricle is more frequently affected, seldom both (Hun). While Gudden affirms, from the fact of its being most common on the left side, that it is solely caused by injury (ill-treatment), Simon believes (*Berl. Kl. Wochenschr.*, 1865) that in imbeciles it is always caused by tissue-changes in the auricle. Roosa (*l. c.*) connects othæmatoma in imbeciles with disease of the brain, relying upon the experiment of Brown-Sequard, who observed the occurrence of hæmorrhage in the auricle after severing the restiform body in animals.

Symptoms.—Othæmatomata appears at the commencement as a bluish-red swelling on the anterior surface of the auricle, rounded or irregular, doughy or hard to the touch. They are seldom distinctly fluctuating on the anterior surface and more rarely on the posterior surface. Spontaneous othæmatomata rarely attain the size of the traumatic. While the former occupy only small sections of the concave surface of the auricle, especially the concha and the intercrural

fossa, the traumatic variety covers the whole anterior surface of the auricle, the swelling sometimes occluding the external auditory meatus, and, as I have seen in one case, it may spread itself on the posterior surface of the auricle, crossing over the superior margin of the helix. In transmitted light the portion where the hæmorrhage is appears dark and opaque.

Spontaneous othæmatomata often develop without any subjective troubles, while the traumatic is mostly associated with great pain, feeling of heat, and tension. By the addition of reactive inflammation severe pain is also felt in a later stage of spontaneous othæmatoma. Subjective noises and disturbances of hearing are only observed when the auditory meatus is occluded by the swelling, or when the membrana tympani is injured.

Course and Termination.—The course of othæmatoma depends on the extent of the hæmorrhage and the degree of the lesion of the cartilage. When the latter is not much altered by the hæmorrhage the termination is far more favourable than when the cartilaginous tissue is fissured by the effusion. In some cases recovery takes place by absorption without malformation of the auricle, while in other cases the latter remains greatly deformed by cicatricial thickening, atrophy, and shrivelling of the cartilage and skin. In a few cases, and more commonly in the traumatic than in the spontaneous form, there occurs an extensive inflammation of the cartilage, which becomes covered with a bloody, gelatinous, and afterwards purulent exudation that may lead to partial ulceration and multiple perforation of the cartilage and of the cutis, and even partial loss of the auricle, or cicatricial deformity of it, with a clefted narrowing of the meatus. Fatal results from pyæmia occur very rarely after gangrenous degeneration.

Diagnosis.—The diagnosis of othæmatoma can be made with certainty when it can be proved that the affection commenced suddenly after an injury. In the spontaneous form the rapid development of the swelling determines the diagnosis, considering that it is impossible to confound it with perichondritis auriculæ, angioma, or a neoplasm.

Prognosis.—The prognosis of traumatic othæmatoma is, owing to absorption without malformation of the auricle, more favourable than that of the spontaneous form, those cases being excepted in which, through injury, there is a deep-seated lesion of the cartilage. It is a favourable sign when the swelling decreases during its course without reaction, but unfavourable when violent inflammatory symptoms are superadded, which require the swelling to be opened.

Treatment.—In the case of small, painless tumours, it is best not to interfere, as all treatment, such as pressure, embrocation, etc., rather tends to renew the bleeding than to quicken the absorption of the extravasation. For this reason, therefore, massage, recommended by Meyer (*A. f. O.*, xvi.), must be used only with great caution, and by no means at the beginning, but first in the third or fourth week. When the swelling is painful neither pressure nor massage must be used. On the other hand, in traumatic and in inflammatory othæmatoma, cold compresses, by means of ice-bags, or Leiter's apparatus, are advisable, and on the cessation of pain, applications of Goulard's lotion. When, notwithstanding antiphlogistics, pain still continues after four or five days, and the swelling has not decreased in size, puncture, letting out the contents, and moderate pressure is the surest method of curing the disease. In many cases the cavity refills with blood, or viscid fluid, so that repeated puncture becomes necessary. When the tumour is of large

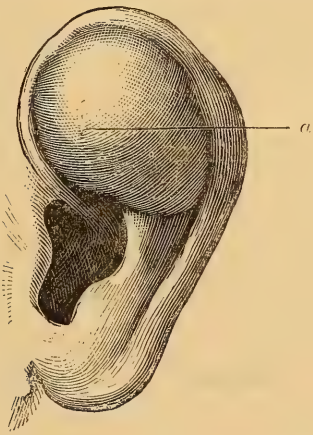

FIG. 86.—Spontaneous othæmatoma on the upper portion of the auricle, occurring in a man aged 23. Puncture of the painful tumour; breaking through the cartilage. Healing of the returning processes by repeated injections of argentic nitrate sol. (2·4 in 10), after its existence for three months.

circumference, R. Chimani recommends the splitting of the swelling, the removal of its contents, and the insertion of carbolic or salicylic wadding or iodoform gauze into the cavity, and afterwards a compress bandage.

Hæmorrhage in the external auditory meatus is most frequently caused by traumatic injuries of the cutis or of the cartilage, and by fracture of the osseous walls. Spontaneous hæmorrhage is rare, and arises usually in those idiopathic forms of inflammation which we describe as otitis externa hæmorrhagica.

2. *Perichondritis of the Auricle* (*Perichondritis Auriculæ*).

Perichondritis is more rarely met with than was formerly supposed. It develops without any known cause, and affects the anterior surface of the auricle without involving the lobe, this being the characteristic of this form of inflammation.

The auditory meatus either remains intact, or the inflammation begins in it and extends to the auricle. In a case observed by Knapp, the affection was complicated with otitis media perforativa.

Symptoms.—At the acme of the inflammation, a red or bluish-red, uneven, fluctuating swelling is found on the anterior surface of the auricle, occupying the greater part of the concha and the fossa helicis, and appearing sharply demarcated below from the margin of the lobe. The temperature of the auricle is increased during the first stage. At first it seems very similar to othæmatoma, but it differs from the latter in its gradual development with inflammatory phenomena and in its contents, which consist of a synovia-like or purulent fluid, but not blood. After long duration of the tumour, it becomes difficult to distinguish it from othæmatoma, because the latter in its later stages sometimes contains no blood, but only a transparent syrupy fluid. Probing the incised tumour reveals a more or less extensive loosening of the perichondrium and denudation of the uneven rough cartilage.

The terminations of perichondritis are: recovery after the formation of an abscess, and discharge of the synovial fluid mixed with pus, without the shape of the auricle being changed (Chamani), or shrivelling and marked deformity of the cartilage, as is observed in the worst forms of othæmatoma (Knapp). In the cases observed, the course was slow, and in one recorded by Knapp, in which the inflammation originated in a furuncular swelling in the meatus, repeated formation of tumours on various parts of the auricle took place. Also in a case of Benni's during a course of three months, the circumscribed perichondritis travelled over the whole anterior surface of the auricle, with exception of the lobule. A similar course was shown in a patient in my clinic occurring in a young girl of otherwise good health. Schwartze saw calcareous and cheesy degeneration result in a case of his. Knapp (*Arch. of Otology*, 1890) saw true ossification occur in a girl of 22 years, following seropurulent perichondritis. The duration of the inflammation varied from three weeks to three months.

The treatment of perichondritis consists at first in the energetic application of antiphlogistics (Leiter's coil), and the early incision

of the fluctuating tumour. Burckhardt-Merian and Urban-Pritchard saw rapid healing take place after puncture, followed by injections of diluted tinct. of iodine (with alcohol āā.). The succeeding treatment by antiseptics, and the application of a pressure-bandage is analogous to that already referred to in the treatment of othæmatoma. Kuhn recommended massage, which proved better, in two cases of his, than puncture and injection.*

As extremely rare occurrences, we must mention gangrene of the auricle (Politzer, Kurckenberg, Eitelberg, Nottingham), and the cases of noma observed by Hutchinson (*Med. Times and Gazette*, 1881). After removal of the necrosed parts and cauterization with nitrate of mercury, recovery followed in the latter case. There is further the affection called by Wilde (*l. c.*, p. 208) pemphigus gangrænosus, which appears behind and on the ears, and is met with frequently among the lower classes in Ireland; it is phagedænic in character, and generally terminates fatally. Rohrer observed a case of simple pemphigus with formation of bullæ as large as a hazel-nut. Jansh and Chiari have also observed a case of a tubercular ulcer of the skin on the left auricle of a phthisical patient.

IV. Contractions and Adhesions of the External Auditory Meatus.

Contractions in the external auditory meatus are caused by infiltration and bulging out of its lining membrane, by cicatrization, or by hyperostosis and osseous new formation on the walls of the meatus, and other forms of new growths. The contractions caused by swelling and hypertrophy of the cutis most frequently develop in the secondary inflammations during the course of chronic suppuration of the middle ear, and further in chronic eczema and in the primary forms of otitis externa. Cicatricial strictures occur in chronic secondary inflammations of the meatus in the course of lingering suppurations of the middle ear, after diphtheritic and syphilitic ulcerations, after injuries and cauterizations (with concentrated acids, galvano-cautery, solid lunar caustic) of the lining membrane of the meatus, and after unskilful sewing of a separated auricle (Bishop, of Chicago). A fissure-like contraction of the orifice of the ear, caused by atrophy, shrivelling and collapse of the cartilaginous wall of the meatus is very frequently met with in old persons. Moure saw a similar narrowing of the cartilaginous meatus in French

* Wilde, *Pract. Bemerkungen über Ohrenheilk, Deutsch. Ueber.*, 1855; R. Chimani, *A. f. O.* Bd. ii.; H. Knapp, *Z. f. O.* Bd. x.; O. D. Pomeroy, *Transact. of the Amer. Otol. Soc.*, ix.; Benni, *Baseler Congressbericht.*

peasant-women and nuns, owing to tightly fastening the cloth or the cap around their heads.

The contractions are either temporary or permanent. Among the first are reckoned the swelling of the cutis, caused by inflammatory infiltration, which, not only in the acute, but also in the chronic forms, recedes spontaneously or after suitable treatment. Sometimes, however, in long-continued infiltration of the cutis, particularly in the course of chronic suppuration of the middle ear, there occurs a new formation of connective tissue with permanent thickening and condensation of the tissue of the cutis, associated with a considerable contraction of the lumen of the meatus.

The strictures caused by ulceration and cauterization are somewhat different. In some few cases there are circumscribed annular strictures, which, as in a case observed by Morpurgo, are like the diaphragm in an optical instrument, enclosing an orifice from the size of a pin-head to that of a small lentil. This condition may easily be mistaken for perforation of the membrana tympani when the slight distance of the new-formed membrane from the external orifice of the ear is overlooked. In other cases permanent strictures remain from extensive callous condensation and shrivelling of the subcutaneous connective tissue, mostly situated in the middle and cartilaginous sections. The contraction is either circumscribed, then affecting generally the middle of the meatus, or it is long, extending usually from the neighbourhood of the external orifice of the ear to the osseous meatus.

Osseous strictures are caused either by a more or less regular periosteal ossification of the walls of the meatus, or by hyperostoses proceeding from the posterior superior wall of the osseous meatus, which, like an inclined plane, sinks from without inwards towards the inferior wall of the meatus, and obstructs the view of the membrana tympani by forming a fissure-like contraction of the lumen of the canal. Such strictures, usually associated with great deafness, frequently develop after carious processes in the temporal bone, especially after exfoliation of large osseous sequestra from the mastoid process through an opening in the wall of the meatus. The slit-like contraction of the meatus, formed by the abnormal inward curvature of its anterior inferior wall, is traced to an anomaly of formation.

The form of the stricture of the meatus is round or fissure-like, seldom like an hour-glass. After exhausted suppuration the contracted part remains long unchanged; in the secreting stage, however, its size varies by the deposition of secretion and by increase and decrease of the swelling of the cutis.

Contractions of the external meatus, even when very pronounced, occasion deafness only when accompanied by pathological changes in the middle ear, or accumulation of thickened secretion behind the stricture. During the existence of suppuration of the middle ear stricture may occasion a fatal affection of the brain or sinus by retention of the pus (Orne Green, Roosa).

In the examination of strictures of the meatus careful probing of the contracted parts is indispensable. For it not only shows the difference of the membranous stricture from the osseous, but also indicates the length of it. If it be short, the point of the probe will move with much more freedom behind the contracted part than when it is long.

The *treatment* of strictures of the external meatus depends on the anatomical cause of the contraction and on the condition of the parts of the external and middle ears lying behind the stricture. In contractions caused by swelling or hypertrophy of the cutis—when they cannot be removed by the treatment spoken of under inflammations of the external meatus—it is advisable to dilate the contracted parts gradually by the insertion of conical, resistant plugs of charpie, which are gradually increased in size. Should the latter prove insufficient, compressed sponge tents should then be introduced, gradually increasing in diameter and allowed to remain till moderate pain is caused by their swelling. This is, as Gottstein rightly observes, preferable to dilatation by means of laminaria tents, which by swelling too quickly often occasion violent reaction and subsequently greater contraction. Energetic attempts at dilatation may even have as their result adhesion of the walls of the auditory meatus, when the epidermic surface is torn off by the pressure of the dilator and the exposed parts touch each other. Rapid dilatation is, however, necessary when it is a question of removing stagnating secretion from the deeper sections of the meatus and of the tympanic cavity in order to check its deleterious effects. By inserting a shortened tympanic tube 10 cm. long into the deeper part of the meatus, and using injections of warm water, such secretion may be most surely removed. The wearing of short vulcanite or silver canulæ is recommended also in the case of fissure-like contraction of the external orifice of the meatus, caused by collapse and atrophic shrinking.

Long-continued contractions caused by hypertrophy of the lining membrane of the meatus prove very obstinate to the methods of dilatation described, as after repeated use of the compressed sponge the contraction again reaches its former degree; sometimes even it increases in consequence of the mechanical irritation. In such cases,

as well as in cicatricial strictures, repeated longitudinal scarifications of the cartilaginous meatus, with subsequent introduction of compressed sponge tents, and the wearing of conically-shaped hard rubber canulas (Fig. 87) prove very effectual. In a number of cases a gradual dilatation was accomplished by wearing tubes of 4-5 progressing sizes. The length of the tube corresponds to the depth of the stricture in the meatus, and can be introduced by the patient himself. Diaphragmatic septa may be permanently removed by circular excision (Ladreit de Lacharrière, Schwartze). Long osseous strictures are incurable, and the method of chiselling out proposed by some is not only useless but dangerous. By progressive but not energetic attempts at dilatation by means of the compressed sponge, continued for months in many cases, slight enlargements may be attained. Too energetic attempts may have an opposite effect. With doubtful symptoms of retention of pus the chiselling away of part of the meatus wall or opening of the mastoid process is advisable (Schwartze).

Contractions of the meatus are frequently caused by *Exostoses of the external meatus.*

Hedinger regards exostoses in general as the result of a hypertrophic inflammation of the lining membrane of the meatus with ossification of the new-formed connective-tissue. Cassells (*Transact. of the Internation. Med. Congr.*, London, 1881) differentiates two kinds of osseous new-formation: hyperostoses and exostoses, the first a hyperplasia, the latter a new growth.

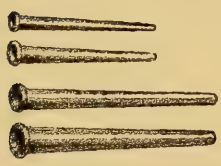

Fig. 87.

According to v. Tröltsch, no sharply-defined line separates the exostoses from the hyperostoses, but he applies the former term to those diffuse osseous growths occupying the whole length of the meatus, and exostoses to the circumscribed, tumour-like osseous new-formations.

The structure of exostoses are either compact, spongy, or hollow. A pedunculated exostosis which I removed showed on histological examination here and there compact lamellæ (eburnation) with a few vessels.

Etiology.—The originating causes of the exostoses are in the majority of cases not ascertained, because there is very little opportunity of observing their development clinically. The following may serve as the origin of a series of cases: 1. Partial hyperplasiæ during the stages of development and ossification of the osseous meatus. To this form, according to my idea, belong those bilateral osteomata arising without symptoms seated symmetrically in the aural

passages, and agreeing on the two sides in regard to form. Their site is the middle and inner sections of the osseous meatus. They are sessile or pedunculate, but never reach such a size as to completely fill the meatus. 2. Circumscribed, chronic periosteal inflammation in the osseous meatus. To these belong the round exostoses (Osteophytes) which, according to Wagenhäuser, occur from traumatic fractures of the anterior wall of the meatus. 3. Diffuse inflammations of the external meatus, whether primary or developed in the course of chronic suppuration of the middle ear. Among these are to be reckoned the ossification of new cartilaginous growths and polypi, and the exostoses in the meatus observed after middle ear suppuration (Dalby). 4. Hereditary tendency (Schwartze). 5. Syphilis (Roosa) and gout (Toynbee) are much more rarely the cause of exostoses than was at one time supposed. That either of these general diseases has given rise to the aural affection can be considered probable only when osseous tumours appear simultaneously on other parts of the body, the origin of which can be traced to the general disease.

FIG. 88.

Moos describes (*A. f. A. u. O.*, ii.) three cases of symmetrical, bilateral exostosis on the superior wall of the meatus, in which two white nodules larger than hemp-seed were seated to the right and left of Shrapnell's membrane. I have noted a number of such in my practice (Fig. 88).

It must, however, remain undecided whether one is here dealing with an osteoma or with a solid connective-tissue tumour. I examined, indeed, more than a thousand skulls and temporal bones without having met with any similar formation in the meatus, and there is just as little information as to such conditions on macerated temporal bones to be obtained from other sources.

The frequent occurrence of exostoses of the meatus among the aborigines of America has been repeatedly confirmed by the investigations of Seligman, Flower, Bernard Davis, Blake, Turner, and Virchow. C. J. Blake also found, while examining numerous skulls of the Mound Builders, exostoses in the auditory meatus in 25 per cent. Virchow found among 134 Peruvian skulls exostoses in eighteen. According to Virchow the location of the exostoses was always the external portion of the bony meatus, and without exception the edge of the pars tympanicus of the mastoid bone; in the inner portion they are never seen, according to Virchow.

FIG. 89.—PEDUNCULATED EXOSTOSIS REMOVED WITH A CHISEL FROM THE LOWER WALL OF THE MEATUS.

Symptoms.—Exostoses of the external meatus appear as white

or yellowish, usually smooth, tumours of various size, seated on the wall of the meatus, either with a broad ill-defined base or sharply demarcated and circumscribed. They may originate in any point of the meatus. Frequent sites of exostoses are the place of union of the osseous with the cartilaginous section and the posterior wall of the meatus (Delstanche, Gardiner-Brown), especially its external section covered by the cartilaginous portion. Exostoses growing on this part are often seen with the naked eye immediately behind the external orifice of the ear, and attain such a size that they convert the lumen of the meatus into a narrow slit. By pressure of the new-formation on the cartilaginous wall, the latter atrophies, till it disappears altogether, or the exostosis adheres to the cartilage so completely that the tumour may be mistaken for an ossifying enchondroma. In a preparation described by Noltenius an exostosis the size of a bean arose from the lower anterior border of the pars tympanicus by means of a small pedestal, and filled the external opening of the osseous meatus.

Exostoses may occur singly or in numbers in the meatus. Often there are found two exostoses, which contract the meatus to a fissure or to an hour-glass shape, completely masking the membrana tympani or allowing only a small portion of it to be seen. Sometimes a small exostosis is placed on the top of a larger one (Moos). Bilateral exostoses are very frequent, but not always symmetrical on the same part of the meatus. Ayres saw symmetrical exostoses in the form of a septum in both meatuses. Once I observed on the left two and on the right three exostoses in the osseous section, proceeding from the anterior, superior and posterior walls; great deafness and tinnitus had lasted since a confinement thirty-one years before. As simultaneous changes in the ear, I have found most frequently chronic catarrh of the middle ear without evident connection with the osteoma, chronic suppuration of the middle ear with or without polypi in the meatus, chronic otitis externa with moderate desquamative secretion and chronic eczema. There are very rarely simultaneous exostoses on other parts of the body. In a Greek, aged forty-four years, who had never suffered from syphilis, there existed, besides an exostosis almost completely closing up the left meatus, an osseous tumour as large as the fist on the left temple, which had gradually reached this size in the course of twenty-four years. In general the examination of patients shows a stationary condition of the exostosis, after a pause of several years. Only occasionally, in suppurative processes, the bony growth may rapidly increase in size. Those cases of spontaneous absorption of exostoses described in the literature are most likely to have been an unorganized periosteal exudate.

The subjective symptoms accompanying exostosis of the meatus are more often caused by simultaneous affections of the middle ear and of the meatus than by the tumour itself. Small exostoses not occluding the canal almost always run their course without symptoms. Large osseous tumours, on the other hand, may give rise to painful inflammation with suppuration by pressing on the opposite wall of the meatus, the exostosis itself being also similarly affected. In such a case I once observed a bed-sore, as it were, with formation of granulation tissue arise on an exostosis. In a case observed by Moos a trigeminal neuralgia was produced by an exostosis which disappeared upon removal of the growth.

As to the further history of exostoses, large ones may, apart from deafness, be injurious by favouring the accumulation of cerumen and epidermic masses in the deeper parts of the meatus, by closing it up and preventing the exit of pus in cases of co-existing suppuration of the middle ear, and by rendering the surgical removal of polypi difficult.

In a case of exostosis observed by Delstanche, which obliterated the external opening of the meatus completely, the growth was fastened to the posterior osseous wall of the meatus by a rather wide base, and showed some movement. The cause of the latter was found after the operation to be due to the softening and absoption of the upper and posterior osseous wall of the meatus by the retention of pus, so that only a small portion remained, upon which the exostosis was situated. If this had existed longer, the suppuration would undoubtedly have produced a spontaneous expulsion of the exostosis.

Diagnosis.—From its characteristic appearance, in my experience the diagnosis of exostosis presents no difficulty. It is only when the lining membrane of the meatus is inflamed and swollen that the red, secreting swelling which may be covered with granulation tissue can be mistaken for the bulging cutis of the meatus or for a polypus. The resistance of the tumour and its usual sensibility on being probed leaves no doubt as to its nature.

Treatment.—When exostoses have attained such a size that great deafness is caused by the complete closure of the meatus, it is better, before proceeding to surgical means, to make some attempts at dilatation. If solid bodies introduced between the exostosis and the wall of the meatus and retained there for a long time succeed in causing atrophy of the exostosis and so establishing a small slit in the lumen of the auditory meatus, that is quite enough for the entrance of the waves of sound. Bonnafont (*Union méd.*, 1863) describes three cases of extreme deafness from exostosis of the meatus, in which normal hearing was restored by a very small

opening being formed through the long-continued introduction of a metal rod between the meatus and the exostosis. Von Tröltsch has observed the circumference of an exostosis decrease after laminaria tents had been introduced for years. In one case, where a piece of the laminaria remaining had caused superficial necrosis of the walls of the meatus, after removal of the small sequestrum a considerable dilatation of the meatus was observed and the hearing returned.

The removal of cerumen and epidermic masses accumulated behind the exostosis by the ordinary syringing is seldom possible, as the stream of water does not enter the opening with sufficient force. In such cases, the desired result is most speedily attained by pushing the point of a tympanic catheter through the opening towards the interior, and then by means of a Pravaz's syringe, the nozzle of which goes into the outer end of the catheter, injecting ten drops of a warm solution of soda in glycerine. The mass so softened can easily be syringed out on the following day with warm water injected by means of a large syringe through the inserted catheter. After removal of inflammatory secretions by repeated syringing of the meatus, alcohol or solution of boric acid in alcohol (1 in 20) should be dropped in the ear. Granulations should be removed by applying Liq. ferri. muriat. or burning with the galvano-cautery.

The indications for the surgical removal of exostoses are the following: 1. Extreme deafness, in consequence of complete closure of the meatus by the exostosis if there is at the same time deafness in the other ear. 2. Suppuration of the middle ear, the escape of the pus from which is prevented by the tumour. In such cases speedy action is the more urgent the more marked the symptoms of retention of pus.*

Of the methods of operation recommended for the removal of exostosis, that by means of the gouge and hammer has proved the best. This has the advantage of quickly removing the new-formation; it requires great caution, however, in deeply-seated exostoses, on account of the possible danger of injuring deeper parts by the slipping of the instrument (Field). This method is particularly suited for those pedunculated exostoses which are removed from their base by two or three short blows with the hammer. According to Knapp the operation is made easier, if instead of directing the chisel directly against the base of the exostosis a thin lamella of the meatus wall underneath it is removed at the same time.

* Knapp (*Z. f. O.*, Bd. XIII.) described an interesting case of successful operation on an ivory exostosis.

The length and breadth of the chisel used varies according to the position of the growth and the breadth of the base upon which the exostosis is situated. I use gouges of 2, 3, 4, 5 mm. in breadth, with more or less pronounced excavation. Chisels with handles placed at an angle are not so safe as the straight. In four cases operated upon by me, after covering the wound surface with iodoform, healing took place within a few days; in exostoses with broad bases, profuse suppuration has occurred. In one case where, during a chronic middle ear suppuration with formation of polypi, an exostosis grew from the posterior wall of the osseous meatus, healing was brought about by the long use of alcohol after the removal with the chisel. In deeply situated exostoses Schwartze proposed to separate the auricle and cartilaginous meatus from behind forwards in order to facilitate their removal, and according to his observation with ordinary antiseptic precautions the auricle united by primary healing, and only a slight reaction followed the chiselling of the exostosis. Favourable results from chiselling have been reported by Aldinger, Cassells, Heinecke, Schwartze, Lucae, Stone, Heimann, and others.

Of other methods of operation to be described: perforation of the exostosis by means of files (Bonnafont), drills, and dentists' drill-machines (Mathewson, Ch. Delstanche, Bremer). This procedure is much less sure, as the perforation very often closes notwithstanding the insertion of ivory or lead pins. The breaking off with a finely constructed pincers (J. P. Cassells, Jaquemart) is only practicable when the exostosis is pedunculated, and is situated near the external opening of the meatus. Even here the removal with chisel and hammer is preferable. Destruction of the exostosis by the galvano-cautery, recommended by Voltolini and Delstanche, is only suitable for those situated in the outer portion of the meatus. It is very slow, but it has this advantage, that the operation gives rise to but slight bleeding and moderate pain. Moos has cured one case by the combined use of the galvano-cautery and the insertion of laminaria tents. For pedunculated tumours with contracted base the elastic ligature recommended by v. Dittel may be used.

Painting the new growth with tincture of iodine and lunar caustic to produce absorption has proved useless. The internal exhibition of iodine and mercurial preparations is only to be advised when the disease is caused by syphilis.

Atresia of the Eternal Meatus.—Acquired atresia of the external auditory meatus is caused: 1. By the immediate contact of the walls of the auditory meatus deprived of their epidermis in the course of secondary inflammation of the meatus, due to chronic suppuration of the external and middle ear. 2. By combined caries and necrosis of the mastoid process and of the walls of the meatus, as, after the expulsion of one or more sequestra, the granulation tissue growing

into the lumen of the meatus is changed into fibrous connective or osseous tissue after adhesion to the walls of the meatus. In such cases there are often contracted osseous cicatrices on the mastoid process, besides osseous atresia of the meatus. 3. By the adhesion of large granulations proceeding from the walls of the osseous section and filling up its lumen, the epithelium being afterwards lost by long contact of the growths. Here also the connective tissue closing the meatus becomes changed into a fibrous mass or into bone.

In a case observed and dissected by me, the osseous meatus was filled with a pigmented connective tissue mass, containing cysts, as the result of chronic otitis externa. It was adherent to the walls of the meatus and external surface of the membrana tympani, there being only a fissure extending to the membrana tympani along the posterior wall. In a case of pedunculate polypus, reaching to the external orifice of the ear, in which operation was not permitted, I found at a later examination atresia of the meatus, caused by adhesion of the polypus on every side with its walls. The necropsy of this extremely interesting case showed a mass of connective tissue, filling the meatus and cavum tympani, which from here had penetrated the vestibule, the facial canal and the internal auditory meatus, and had entered the cranium. In the posterior fossa of the skull were several connective-tissue growths, varying from the size of a pea to a hazel-nut, underneath the dura-mater and connected with the mass of connective tissue coming from the internal meatus.

4. By traumatic lesions (Samuel Sexton), cauterization, burning and ulceration of the walls of the meatus. Adhesion in these cases is caused either by the contact of the exposed walls or by the contact of the granulations rising from the surface of the tumour. 5. By a phlegmonous, periauricular inflammation extending into the meatus, with the formation of a mass of adhesive connective tissue in the cartilaginous portion (Ladreit de Lacharrière).

Fibrous atresia is caused either by a membranous septum stretched out usually at the entrance to the ear or in the osseous section, or by a long mass of connective tissue varying in thickness. Osseous atresia, usually of considerable thickness, is oftenest situated in the external section of the osseous meatus, the whole canal being seldom filled up by the osseous masses.

The objective symptoms of atresia vary according to its seat and extent. In the fibrous as well as in the osseous forms of atresia the walls of the meatus run up to the adhesion without clear demarcation, thereby giving the canal the appearance of a *cul-de-sac*. The further the atresia extends outwards the shorter appears the canal of the ear. This is of importance in the diagnosis of atresia. It is

only when it is limited to the innermost section of the osseous meatus that the surface of the adherent parts may be mistaken for the membrana tympani. The adhesion existing between the walls of the meatus on all sides and the background, the absence of the short process and of the handle of the malleus, and the diminished distance from the external orifice of the ear to the inner end of the meatus compared with that of the other side, are sufficient guides, however, for the diagnosis of atresia.

Further, the adherent parts must be probed in order to ascertain whether the adhesion be membranous, fibrous, or osseous. In the last case the background is hard as bone. It is more difficult to distinguish between a membranous septum and an extensive connective-tissue adhesion, particularly when the expanded membrane is somewhat thick and not very yielding.

In such cases the degree of hearing sometimes informs us of the thickness of the atresia. In osseous atresia or in extensive connective-tissue adhesions there is total deafness, or nearly so, as in a case of Moos's, in which there was a bilateral osseous atresia after periostitis produced by eczema; in membranous closure (septum), on the other hand, there may be a considerable hearing-distance for speech. As, however, perception for loud speaking is partly transmitted through the bones of the head, it is advisable to use an ear-trumpet in testing the distance for speech. In osseous or extensive connective-tissue adhesions what is spoken through the ear-trumpet is either not heard at all or is understood with difficulty. In membranous closure of slight thickness, however, even low speech can be understood, provided that the tympanic apparatus and the labyrinth have undergone no great changes. When whispering is understood through the ear-trumpet it is very probable that the septum is very thin; and this is of practical importance in so far that in such a case one can at once have recourse to surgical treatment of the atresia, while in cases in which speech is not understood with the help of the ear-trumpet surgical interference is useless.

A girl twelve years of age had suffered at the age of two from left otorrhœa, and two years later from right otorrhœa also. At the age of nine years the discharge stopped in both ears. The examination gave as result: symmetrical *cul-de-sac* closure of both meatuses almost in the middle of the osseous section (*cf.* diagrammatic sketch of the right meatus, Fig. 90). The background is yellowish-white, and somewhat yielding on being probed. Hearing-distance right and left for the acoumeter 1 cm., for loud speech 15 cm. Through the ear-trumpet whispering is well heard on both sides.

Supported by the results of this testing, I proceeded to divide the septum with the paracentesis needle. On the right ear the hearing improved 8 cm.

for the acoumeter and 5 metres for speech; on the left the septum proved to be thicker and more resistant, and the improvement in hearing was less than on the right. After the operation, to prevent renewed adhesion, leaden pegs* were introduced and allowed to remain with few interruptions for several weeks. The result was: on the right, persistency of the opening by the formation of epidermis on the severed edges of the septum and permanent improvement in the hearing; on the left, moderate reaction at the seat of operation and, later, recurrence of the adhesion of the meatus.

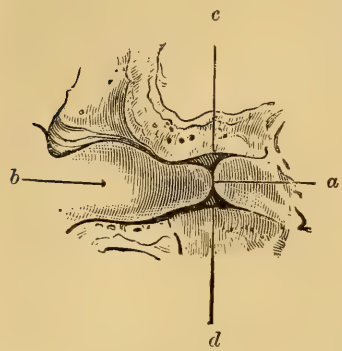

FIG. 90.

a, Cartilaginous meatus; *b*, Septum in the osseous section; *c*, *d*, Peripheral thickened part of the septum.

In cicatricial closure of the cartilaginous meatus in the neighbourhood of the external orifice of the ear, especially when of great thickness, simple incision and the insertion of leaden pegs have proved insufficient, and it is in such cases that partial excision of the cicatrix is necessary before the introduction of tents (Ladreit de Lacharrière, Samuel Sexton).

In a case reported by Rothholz a tendinous gray pseudo-membrane, due to chronic otorrhœa, completely closed the right meatus 3 mm. in front of the membrana tympani. By means of a radial incision and insertion of cotton tampons permanent healing resulted, after which there was a marked improvement in hearing and the subjective noises disappeared.

V. Foreign Bodies in the Ear.

Foreign bodies in the external meatus most frequently come under observation in the case of children, who insert into their ears such various things as peas, beans, pieces of paper, cherry-stones, coffee-beans, carob-stones, pebbles, glass beads, wooden balls, fruit-stones, sealing-wax, slate-pencil, metallic buttons, grains of shot, and so on. In adults, foreign bodies get into the meatus mostly by accident. According to my experience, the most common are pieces of camphor and of garlic, which have been put into the meatus to allay the pain of toothache or earache, and objects used for picking the ear, especially the bone or porcelain heads of small lead pencils, less frequently rolls of paper, tooth-picks, matches, and ear-picks. Besides these, pellets of cotton-wool, leaves, and pieces of branches, grains of wheat and millet, oats and barley, etc., sometimes get into the meatus.

* The introduction of correspondingly thick leaden tubes is preferable to that of leaden pegs, as the wearing of the former assists the hearing.

Symptoms.—The symptoms which foreign bodies give rise to are by no means so serious as was at one time thought. Experience has taught that the consequences attributed to foreign bodies are, with few exceptions, due to the awkward attempts made at extraction by non-professional hands.

In a considerable number of cases which were examined for other disorders of hearing, I found the greatest variety of objects in the meatus, of which the patient had not the slightest idea, and which must have lain in the ear for a very long time. Once I found a slate-pencil 3 cm. long which, according to the patient, aged seventy years, had lain there for fifty years. As the patient found no inconvenience from it he allowed it to remain, till deafness, caused by a ceruminal plug, forced him to seek medical aid. One of my audience at a discourse on foreign bodies informed me that twenty-two years before a slate-pencil had been put into his ear, but had fallen out again of its own accord; nevertheless, I found the pencil 1 cm. long in his meatus. Similar observations have been recorded in large numbers in both the old and new literature. Brown found in both meatuses of a boy several pebbles which had remained there for seven years. In a case of Lucae's a cherry-stone had remained in the meatus forty years, in another case of Zaufal for forty-two years. Reim removed a back-tooth from the ear which had been there for forty years; Maschal removed a coral bead which had remained for forty-five years in the meatus; Marian removed a glass bead from the ear of a peasant which had been there since childhood.

Sometimes, however, foreign bodies not only cause violent reflex phenomena in the course of the trigeminus and vagus nerves supplying the external meatus, but also occasion long-persistent general nervous attacks which only disappear after the extraction of the foreign body.

The literature of otology is rich in suitable examples, but only a few of the most interesting need be given. Arnold (cited by Moos) found in a girl that the cause of a persistent cough with frequent vomiting was the presence of two beans in the auditory meatuses. After these were removed she quite recovered. In a case of Toynbee's (*l. c.*), an obstinate cough ceased after the extraction of a sequestrum of bone. I have observed a similar case in my practice. Fabricius von Hilden (cited by v. Tröltsch) cured a girl suffering from epilepsy, a dry cough, anæsthesia of one half of the body, and atrophy of the left arm, by removing a glass bead which had lain in the meatus for eight years. Maclagan (cited by Wilde) and Küpper saw healing of epilepsy and deafness after removal of foreign bodies from the ear.

On the whole, however, the worst consequences of foreign bodies in the ear are due to violent attempts at extraction. In this way not only is the meatus, and sometimes also the membrana tympani, injured, but the body lying in the cartilaginous section is driven into the osseous section, and either impacted at the narrowest part of it or after rupture of the membrane forced into the tympanic cavity.

Such attempts, usually attended with severe bleeding, give rise to traumatic otitis externa and sometimes also to purulent otitis media accompanied by great dizziness, in consequence of which the auditory meatus becomes so contracted by swelling and granulations that the foreign body is lost to view and its removal is rendered very difficult or altogether impossible.

In the course of such inflammations the swelling in the meatus may recede spontaneously under suitable treatment, and the removal of the foreign body may be rendered easier. Very often, however, the imprisoned body maintains the inflammation and suppuration so long that it is either spontaneously discharged or extracted. When the lesion and inflammation are limited to the external meatus, cure is almost always effected, even after long continuance of the affection. But when the membrana tympani has been injured and suppuration of the middle ear has occurred, extensive destruction of the membrane with great deafness often remains and facial paralysis may occur (Stacke). In one of my cases there existed, in addition, constant violent tinnitus, hyperæsthesia acoustica, and persistent headache.

That coarse attempts at extraction may also cause complications dangerous to life by injury to the walls of the cavum tympani and labyrinth is proved by recorded cases of fatal termination in consequence of meningitis, abscess of the brain, and sinus-thrombosis (Weinlechner, Fränkl, Wendt, Lucae, Zaufal, Moos, Lewi, etc.).

Diagnosis.—At the examination of the meatus the first thing is to make sure of the presence of a foreign body, as it often happens in the case of children who say they have put something in the ear, that nothing can be discovered. In several such cases I have found the meatus injured by former coarse attempts at extraction. Pilcher (cited by Th. Barr) and Szokalski have even observed such blind attempts result fatally from meningitis, and especially from erosion of the carotid; Lucae once observed injury and caries of the inner wall of the tympanic cavity and complete deafness.

After having ascertained the presence of a foreign body, its size, form, consistency, and position have next to be made out. Frequently a glance is sufficient to recognise the body, but very often when it is lodged deeply or covered with effused blood or secretion it is more difficult to judge, as children are often unable to say what kind of body they put into the ear.

Treatment.—The method of removal of a foreign body depends upon its seat, consistency, size, and form, and upon the state in which the ear is found at the first examination; that is, whether

no attempt has yet been made at extraction, or whether the meatus has not already been injured, inflamed, and swollen by violent attempts at removal.

The removal of foreign bodies from the ear is, with few exceptions, very easy and simple, provided that no difficulties have been created by previous attempts. The latter occurrence is unfortunately so frequent that, according to my notes, scarcely 10 per cent. of the cases come untouched to the specialist. In the majority of cases the body has been forced inwards and impacted, with injury to the meatus and the membrana tympani, by the anxious relatives or by a medical man not acquainted with the subject.

The surest and best way of removing foreign bodies from the ear is by the use of strong injections of tepid water by means of a large English syringe, to the end of which is attached a short india-rubber tube (Lucae), or the rubber tube rounded at the end as proposed by me. By pushing it up to the foreign body the strength of the injection is increased, and the body is so much the more quickly and surely expelled. Voltolini and Hedinger recommend for heavy bodies—for example, grains of shot—that the injections should be made with the patient lying on his back and the head inclined backwards, so that the body can the more easily be washed out of the sinus of the inferior wall of the meatus.

When foreign bodies have not been disturbed by any attempts at extraction, as unfortunately too often happens, any other method than syringing is rarely required. Injections are contra-indicated when the foreign body is the head of a pencil and its cavity is directed outwards, for then by strong syringing the water would enter the cavity and force the body inwards, and cause it to be impacted; also, when the membrane is perforated, as then injections would cause dizziness, or the water would escape by the Eustachian tube. Of 109 cases of foreign body in the ear, Zaufal removed 92 by syringing; in 17, owing to previous improper manipulation, instrumental means were required for removal.

Zaufal recommends injections of oil instead of water when the body is one that would swell. But leaving out of account the slight expulsive force of oil injections, we consider this precaution unnecessary, because, in cases in which the body cannot be got out after several strong water injections, its enlargement may be prevented by immediately pouring alcohol into the ear. The instillation of oil or glycerine, as Noquet suggests, facilitates the removal of bodies when syringing with water.

If the body is so firmly fixed in the meatus that it cannot be got out by strong injections, it is advisable to try the agglutinative method recommended by Loewenberg before proceeding to operative measures. This consists in dipping the point of a medium-sized camel-hair brush into a concentrated

solution of glue and inserting it into the meatus so as to bring it into contact with the foreign body, which has been previously dried. By the drying of the thick fluid the brush sticks so hard to the body that it can be drawn out when there is not too much resistance. This proceeding is very suitable for bodies liable to swell, wooden balls and cherry-stones, but only when there is no inflammatory secretion in the meatus, as that prevents the drying of the glue. For pebbles freshly-prepared cement is preferable to glue. For glass or steel beads with the opening turned outwards Lucae recommends a fine moist laminaria tent, to be pushed into the orifice of the bead, which may be removed at the end of half an hour, when the tent has expanded.

Operative Methods.—As to the surgical methods employed for removing foreign bodies from the ear when injections and the agglutinative method have been tried without effect, no rule can be given, as they must be regulated by a number of circumstances, which vary in each case. While the formation of the meatus, its width, and curvature, present many individual varieties, the situation is still further modified by the size, form, consistency, and position of the foreign body, and by the presence of already-commencing inflammation, swelling, or contraction of the meatus. The proper proceeding to be adopted in each case is determined by a correct judgment of the circumstances, and, here more than elsewhere, the success of the operation depends on the acuteness of the surgeon.

In every case, also, in which previous attempts at extraction have failed, the surgeon must consider well whether it would be better to operate at once or to postpone operating till more favourable circumstances present themselves. If the chances are favourable, then it is better to operate at once, especially when the meatus has been injured by previous attempts at extraction, as in that case the inflammation so set up may take an unfavourable course, owing to the presence of the foreign body. Immediate operation is also advisable in cases in which a persistent cough or other troublesome reflex symptoms are caused by the foreign body. It is better to wait patiently when there is no danger to be feared, or when, the body being situated deeply and there being coincident inflammatory contraction of the meatus, operative treatment is impossible. The application of cold by means of Leiter's apparatus and the insufflation of boracic powder or the instillation of spirituous solution of boracic acid are here recommended in order to allay the swelling in the meatus; and only when the body can be seen should further steps be taken to remove it. In complicated cases, especially with children, it is better to operate in light narcosis.

If the body—for example, a pea, bean, a swollen carob-stone, or

a wooden ball—be wedged in the narrowest part of the meatus, or seated in front or behind its isthmus, and by the great swelling pressed on all sides immovably against the walls of the meatus, extraction is best accomplished with a strong curved hook (Fig. 91) or with a firm needle with its point at right angles to its long axis (Fig. 92).

The instrument fixed on the handle is, in the case of bodies impacted not more deeply than the commencement of the osseous meatus, introduced so that it is pushed with its hook horizontal between the body and the upper wall of the meatus till it gets behind the foreign body. It is then turned so that its point is directed towards the body. The handle is next pressed upwards as far as possible, so that the point of the hook may penetrate deeply into the body in order to ensure its removal as safely as may be. When, however, the body is situated in the inner section of the osseous meatus it is better to insert the hook between the anterior inferior wall and the body, for by pushing it along the superior wall the posterior superior part of the membrana tympani might very easily be injured.

Fig. 91.

Fig. 92.

Instruments like corkscrews, recommended for the extraction of objects that may swell, are of little use, as they generally straighten when the body is firmly wedged.

On the other hand, especially in the presence of traumatic inflammation, we must condemn the use of the galvano-cautery, recommended by Voltolini, for burning foreign bodies, as the inflammation is increased by the combined action of the radiating heat. According to my idea the galvano-cautery is only suited for such an object as an impacted cherry-stone, in which a hole might be burned for the introduction of an extraction-hook. Hedinger destroyed a piece of cork tightly fastened in the meatus by means of the galvano-cautery. Howe roughened a smooth piece of lead wedged in the isthmus by the same means, so that it could be seized by the extraction forceps and removed.

For deeply impacted bodies liable to swell, when the membrana tympani is perforated, strong currents of air (Hedinger) and injections through the Eustachian tube should be tried before proceeding to surgical means. In this way foreign bodies have been several times washed out from the ear (Deleau, Lucae).

The procedure is very different in the case of hard foreign bodies, such as pebbles, glass beads, slate-pencil, cherry-stones, etc. If the body is impacted in the cartilaginous section its removal is in most cases very easily effected, as by the insertion of a slightly-curved or hook-shaped probe (Burckhardt-Merian) behind the body, it is removed without any difficulty.

Fig. 93.

Of all the instruments used for the removal of foreign bodies I have found most useful the fenestrated curette (Fig. 93), the scoop-shaped steel lever of Zaufal, Lister's blunt hook, Guye's fenestrated forceps, Tiemann's bullet-forceps, Sapolini's needle-shaped pointed pincers, Trautmann's lock forceps, or the gouge forceps. The use of common forceps must be avoided, as they only wedge the foreign body more firmly.

The removal of hard bodies situated in the narrowest part of the meatus, pushed behind the isthmus or into the tympanic cavity, is exceptionally difficult. This refers more particularly to irregular bodies, such as pebbles, slate-pencils, glass beads, etc., which in certain positions easily pass the narrowest part of the meatus, while on the slightest touch the position so changes that the largest diameter lies across the axis of the meatus.

The removal of such bodies from the deeper sections of the meatus depends upon their size and position and on the relative capacities of the meatus. In some cases the extraction is very easily accomplished, as the body can be loosened by careful manipulation and its position changed. In the case of a boy who had six pebbles in his ear, and in whom no previous attempts at extraction had been made, I got all of them out very easily by means of a slightly bent probe. In other cases again, all attempts at extraction completely fail; the extraction must then be postponed till the conditions become more favourable, or, when dangerous symptoms appear (increased temperature, optic neuritis and choked disc, Zaufal, *Prag. Med. W.*, 1891), the auricle and the posterior wall of the cartilaginous meatus must be detached, and even the posterior wall of the meatus chiselled away, in order that the body may be extracted by that way.

The separation of the auricle for the removal of deeply imprisoned bodies was recommended by Paul von Ægina (see Lincke, p. 586). In recent times the operation has been again revived by surgeons and ear specialists with good results. Isreal (*Berl. Med. W.*, 1876) succeeded in removing an impacted button, Moldenhaur and Bezold impacted pebbles, Huber a ball of wood, and Politzer a carob-stone from the cavum

tympani after removing the auricle. After the separation of the posterior wall of the meatus as deeply as possible, Moldenhauer recommends the use of small, smooth and grooved levers, bent at an obtuse angle in various directions, for picking out the body.

Foreign bodies are often retained in the cavum tympani without trouble. Occasionally, however, they produce severe inflammatory results, dizziness, and nervous headache. If in these cases it is not possible to remove the body into the meatus by means of sounds, small levers, or injections through the tube, nothing remains but to separate the auricle, by which means, however, the wished-for result cannot always be obtained, as shown by experiments on the cadaver. V. Tröltsch removed a metal ball from the cavum tympani with Wilde's snare.

In some few cases foreign bodies also reach the tympanic cavity from the naso-pharynx. Urbantschitsch (*Berl. klin. Wochenschr.*, 1878) saw an oat-husk, which had stuck in the throat while chewing an ear of grain, wander through the tube into the tympanic cavity and into the external meatus. Schalle (*ibid.*, 1878) communicated a case in which, during the application of the nasal douche by means of a vulcanite syringe, a piece broken off from the latter reached the tympanic cavity and there caused acute suppuration, and was removed by incision of the membrane.

Among foreign bodies in the ear are still to be mentioned insects which penetrate into the auditory meatus (the house-fly, fleas, bugs, beetles, especially the earwig, cockroaches, etc.). They often stick in the cerumen and die in the ear, without causing any sensation. In one case I found in the softened mass of a ceruminal plug a fly, a bug, and a beetle.

When, on the other hand, living insects reach the osseous meatus and the membrana tympani, they often cause violent noises and very painful sensations: headache, convulsions, and vomiting. A miller, whose membrana tympani was for a few minutes struck by the fore-feet of a cockroach which had become fixed in the isthmus, affirmed that he was driven nearly mad. The insect, which was killed by pouring in oil, was driven still deeper in by attempts at extraction, and had to be removed in pieces by syringing. Rohrer removed a living butterfly from the meatus, which during the two days it remained there, produced subjective noises and pain; Truckenbrod removed a living cockroach from the inner half of the osseous meatus by means of a pincette.

Insects are most rapidly killed by pouring oil into the meatus; the ear should then be syringed with warm water.

Although the feeling as if there were an insect moving about in the ear sometimes depends only on irritation of the nerve in the meatus, I would still recommend, even in all those cases in which examination with the speculum gives a negative result, that the

ear should be syringed. In a case in which the patient attributed an extremely troublesome and painful sensation in the ear to the presence of an insect, no sign of a foreign body could be discovered on the most minute examination, but, after syringing, a gray spot was noticed on the surface of the water, which proved to be an exceedingly small bug. In a man who complained for a short time of troublesome noises in the ear and gave as the cause of it that an insect had entered the meatus, Drs. J. Pollak and Hrubesch found in the water with which they had syringed the ear, a very small spider, which had remained undiscovered during the examination with the speculum.

The larvæ of the blue-bottle fly, which sometimes develop during summer in the ears of children with neglected, offensive discharges, must be mentioned, as they often remain for a long time in the ear without marked symptoms, but sometimes produce delirium by the severe pain. They adhere so firmly by their suckers, usually in depressions of the tympanic cavity, that they can be removed seldom by syringing, and forceps scarcely ever succeed better. Such larvæ are most surely removed by dropping oil or glycerine mixed with a few drops of petroleum, turpentine, or an ethereal oil into the ear. Some minutes after the instillation the larvæ leave their hiding-place and creep out of the meatus.

The new growths, neuroses and injuries of the external ear, on account of their frequent complication with those of the middle ear, will be described with the general affections of the sound-conducting apparatus.

II.

THE DISEASES OF THE MIDDLE EAR.

A. The Diseases of the Membrana Tympani.

The pathological changes in the membrana tympani develop either following primary disease of the membrane, or secondary to diseased processes which extend to the membrane from the external or middle ear. We will first give a general survey of the most important histological changes of the membrane, and in the following division we will chiefly discuss its primary affections, while the secondary changes will be considered in the description of the diseases of the external and middle ear.

Survey of the Histological Changes in the Membrana Tympani.

I. *Changes in the Epidermic Layer of the Membrana Tympani.*

In acute inflammations the delicate, transparent layer of epithelium is loosened by being saturated with and macerated by serum, becomes opaque and non-transparent, and is sometimes raised in the form of blisters. Detachment of the epidermis and reproduction of the epithelial layer usually take place shortly after the inflammation has ceased.

In chronic inflammations of the membrane an abundant growth of epithelial cells very frequently occurs, not uncommonly producing an abnormal thickening of this layer, especially secondary to chronic otitis ext., chronic eczema, and after otitis med. suppurativa (otitis desquamativa, Buck). The detached epidermic masses consist of swollen and fatty epidermic cells, of free fat-globules and debris, with often considerable quantities of cholestearine crystals and pigment.

In some rare cases the circumscribed hypertrophy and cornification of the epidermic layer takes place, or, as in a case of mine, the formation of a pointed, horny growth which could not be detached from the membrana tympani. Urbantschitsch (*A. f. O.*, vol. x.) first noticed, in the course of middle ear inflammation, small pearl-shaped nodules on the membrana tympani and external meatus containing epithelial cells.

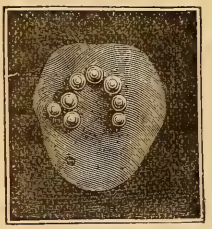

Fig. 94.—Globular Pearly Growths on the Left Membrana Tympani of a Young Man, who had had an Affection of the Ear for a Year.

In a case observed by me after a middle ear suppuration, there was on the upper half of the membrane (Fig. 94) eight pearly balls of a bright lustre and the size of a pin-head. They proved upon probing to be hard and firmly attached, containing cholestearine crystals and fine-celled detritus. Küpper saw a cholesteatoma 15 mm. in size situated in front of the umbo in a phthisical patient.

Desquamation and condensation of the epidermic layer of the membrana tympani are, as a rule, associated with great opacity of the membrane. These opacities can be distinguished from those caused by the mucous layer, since in the latter the handle of the malleus is distinctly visible, while it is very indistinct in cases of slight epidermic thickening, and invisible in cases of great thickening. As a matter of course with deposits of that kind, anomalies in the curvature and in the extent of the visible surface of the membrane will also be combined, and the membrane will be found to be either flat or uneven and rough, the boundary between it and the meatus being obliterated.

II. *Changes in the Dermic Layer of the Membrana Tympani.*

Hyperæmia and Hæmorrhage of the Dermic Layer.—The vascular network of the membrane is not visible in the normal ear, but an increased

supply of blood, due to irritation or inflammation, renders it plainly visible, sometimes in patches, sometimes over the whole membrane. Even by mechanical irritation of the membrane, such as a lengthened inspection with speculum and mirror (v. Tröltsch), or by irritation of the meatus with hard bodies, great hyperæmia may be produced in the normal membrane. In disease the excessive supply of blood to the membrane is frequently combined with hyperæmia of the lining membrane of the external meatus, more frequently still with a similar condition in that of the tympanic cavity; and rarely is it the consequence of a local inflammatory irritation of the membrana tympani itself.

Hyperæmia of the membrana tympani always commences with an overfilling of the bloodvessels of the handle of the malleus, which extend as a red stripe along the posterior margin of the handle to the umbo, and are generally in connection with the hyperæmic vessels of the superior wall of the meatus. Often the handle of the hammer is so completely covered by the bloodvessels that its locality and direction are only recognisable by the injected vascular bundle.* If the excessive supply of blood increases, an injection of the circular vascular wreath situated near the periphery of the membrane will also take place, from which radiating branches extend towards the centre of the membrane, and come into connection with the bloodvessels of the handle of the malleus. In still more intense hyperæmia the capillary meshes of the dermic and mucous layers become so injected that the membrane appears uniformly light red, purple, or copper-coloured.

Hyperæmia of the handle of the malleus often occurs in certain forms of acute or chronic inflammation of the external meatus and middle ear, also accompanying active and passive congestive conditions of the cranial vessels.

Ecchymoses in the membrana tympani take place either through mechanical contact with hard bodies, or through concussion from sudden condensation and rarefaction of air in the external meatus, farther in ruptures, in persons who were hung or died from strangulation (Hoffmann, *W. Med. Presse*, 1880), then in acute myringitis and acute otitis media, and in inflammations in the course of typhus, scurvy, variola (Wendt), very often in influenza and sometimes in paroxysms of coughing (Trautmann). They appear on the membrane, sometimes as sharply defined, sometimes as indistinct, blackish-brown, irregular spots, which migrate, as was first observed by v. Tröltsch, from the place of their origin toward the periphery of the membrana tympani and from there into the external meatus. This migration is, in my opinion, connected with the eccentric growth of the membrane.

Inflammation of the Dermic Layer.—The dermic layer of the membrana tympani is frequently the seat of inflammation in primary as well as in secondary myringitis. In acute superficial inflammation the exudation is discharged below the rete Malpighii, as a clear or purulent fluid, or as a hæmorrhagic exudate (Bing), by which the epidermic layer is raised in blisters. Only rarely does a fibrinous exudation upon the surface of the

* Compare my *Beleuchtungsbilder des Trommelfells*, 1865.

membrana tympani take place in the form of an easily removable pseudo-membrane. When the whole dermic layer is inflamed the interstitial tissue is loosened by dilatation of the bloodvessels and by infiltration with serous fluid and round cells. In such cases the increase in bulk of the much-

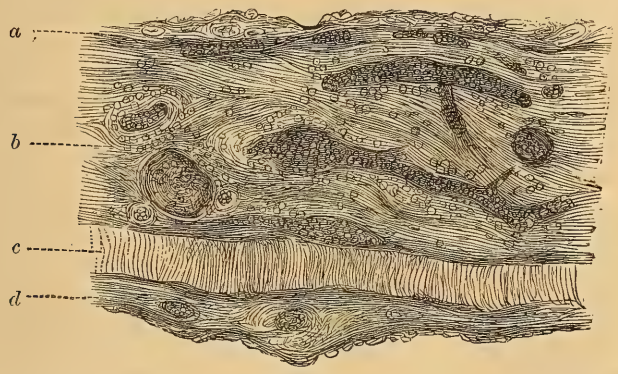

FIG. 95.—SECTION OF THE INFLAMED MEMBRANA TYMPANI OF A WOMAN, WHO DIED FORM PUERPERAL FEVER, DURING WHICH SHE SUFFERED FROM OTITIS MEDIA ACUTA WITHOUT PERFORATION OF THE MEMBRANE.

a, Epidermic layer; *b*, Dermic layer greatly loosened, and traversed by large blood-vessels and pus-cells; *c*, Substantia propria hardly altered; *d*, Layer of mucous membrane moderately infiltrated, and irregularly swollen.

thickened membrana tympani (Fig. 95) is chiefly caused by loosening and thickening of the dermic layer (*b*), while the substantia propria (*c*) is almost unaltered, and the mucous layer (*d*) only slightly so. The surface of the membrana tympani generally appears uneven and glandular.

These changes in the dermic layer are capable of complete resolution. After acute inflammation, chronic desquamation of the epithelium or thickenings and opacities caused by new formation of connective tissue rarely remain, and usually with simultaneous changes in the substantia propria. Excoriation and perforating ulceration is very uncommon after acute inflammation.

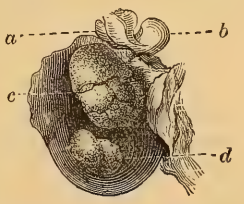

FIG. 96.—GLOBULAR, LOBULATED POLYPI ON THE EXTERNAL SURFACE OF THE MEMBRANA TYMPANI OF A GIRL, 19 YEARS OF AGE, WHO DIED OF CONSECUTIVE MENINGITIS.

b, Head of the hammer; *a*, *c*, *d*, Polypus.

The pathological changes of the dermic layer in chronic inflammations are of greater importance. The increase in bulk of the cutis, accompanied by secretion, leads to uniform thickening of the membrane, or to the formation of granulations and papillary excrescences, covered with a pavement epithelium (myringitis villosa, Nassiloff), or in some rare cases to the formation of polypi (Fig. 96).

III. *Changes in the Substantia Propria.*

Pathological changes in the substantia propria of the membrana tympani must generally be regarded as secondary alterations, produced by disease of the dermic and mucous layers. The occurrence of primary inflammations of the substantia propria is without doubt, it having been ascertained by the investigations of Moos that vessels exist in that layer.

In acute inflammations of the membrana tympani the tissue of the middle layer is loosened and degenerated, and granules, or round cells, are deposited between the fibres. Sometimes, however, the structure is only slightly altered.

The tissue-changes are greater in chronic inflammations, especially in the suppurative affections of the middle ear. In these cases a large amount of exudation is effused by the adjacent inflamed layers into the substantia propria, which appear as irregular, yellowish patches while the secretion lasts, but after suppuration has ceased appear as grayish-white, chalky, sharply defined spots. Frequently, especially in adhesive processes, after middle ear suppuration, the membrana tympani appears rigid, and several times as thick as normal, not unlike a thin leather or cartilaginous plate, from great hypertrophy of its dermic and of its mucous layer to a less extent.

Exudation into the substantia propria may be completely reabsorbed, but, owing to the slight vascularity of this layer, there often remain, especially in chronic inflammations, traces of exudation which undergo calcareous metamorphosis. These calcareous concretions in the membrana tympani, known to Cassebohm,* are frequently observed. They occur most commonly in the course of chronic suppuration in the middle ear, more rarely, as Moos first stated, in chronic inflammations of the middle ear, unaccompanied by suppuration. When the thickness of the calcareous deposits is only slight, this change is confined to the substantia propria, but when it is considerable, the external and internal layers of the membrana tympani take part in the process of calcification. In extreme cases of this kind, the thickness of the membrana tympani is increased several times, the external surface of the membrane is smooth, while the internal is uneven, and appears as if covered with a mass of plaster of Paris. Such membranes, when touched with the probe, are found to be non-elastic and hard, like an egg-shell. The peripheral portion of the membrane generally remains free from calcareous deposit.

When the membrana tympani is considerably thickened, the fibres are infiltrated with minute fat-globules and granules, here and there completely replaced, so that, in sections, the three layers can no longer be distinguished from each other. V. Tröltsch found in one case crystallized calcareous deposits; Bauer, in the membrane of hemicephalic individuals, found crystals of phosphate of lime. In the calcified portions a black, or blackish-brown pigment (Toynbee) will sometimes be found, in roundish masses or striæ, or in spindle or star-shaped cells, and fat-globules are everywhere present in different proportions.

Besides the calcareous deposits, a real osseous new-formation in the

* *Tractatus quatuor anatomici de aure humana*, Halae, 1734.

membrana tympani has in some rare cases been found. The occurrence of such osseous formations in the human membrane was first ascertained and described* by me, and was afterwards confirmed by Wendt and Habermann. In one case observed by me, I found in the calcified membrana tympani of a young man who had died from tuberculosis, and who had suffered for some time from discharge from the ear, a true osseous formation 0·5 mm. in size, behind the handle of the malleus (Fig. 97).

Wendt found a cholesteatoma on the inner surface of a perforated membrane as a reddish, uneven protuberance, with a golden lustre, which had developed from the substantia propria, and, according to Wendt, from the endothelial sheaths of its striæ. Hinton saw a lamellar cholesteatoma above

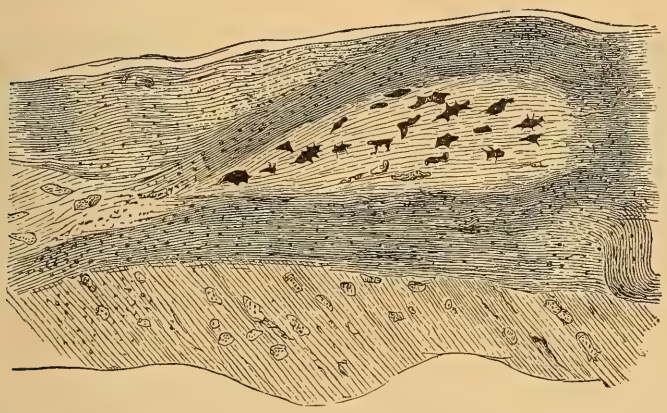

FIG. 97.—OSSEOUS NEW-FORMATION IN THE MEMBRANA TYMPANI OF A YOUNG MAN WHO DIED OF PULMONARY TUBERCULOSIS.

the short process of the malleus the size of a pea. A. H. Buck† observed in one case an interlamellar cyst in the membrana tympani.

IV. *Changes in the Mucous Layer of the Membrana Tympani.*

The mucous layer of the membrana tympani suffers many alterations in the diseases of the middle ear. Hyperæmia of the dense vascular network of the internal layer in acute inflammations is rare, and only for a short time unaccompanied by hyperæmia of the dermic layer. Ecchymoses in the mucous layer are less frequent than in the dermic layer, and occur more rarely in primary, acute affections than in intercurrent, acute inflammations during the course of chronic affections of the middle ear, and in cases of concussion of the membrana tympani. They may completely disappear, or their pigment may remain.‡ Dilated, varicose, lymphatic vessels with saccular

* Compare my treatise, *Zur pathologischen Anatomie der Trommelfelltrübungen und deren Bedeutung für die Diagnostik der Gehörkrankheiten. Oesterr. Zeitschrift f. pr. Heilk.*, 1862.

† *Med. Record*, vol. vii., and Roosa's *Diseases of the Ear*, p. 222.

‡ Wendt observed in patients afflicted with smallpox the occurrence of small hæmatomata in the mucous membrane of the membrana tympani.

expansions, such as I was the first to describe, in the deeper layers of the mucous membrane of the middle ear, I have seen in two preparations of the membrana tympani (chronic perforating inflammation of the middle ear).

The exceedingly thin layer of connective tissue in the mucous membrane, inseparable from the substantia propria, may become hypertrophied by proliferation, growth of round cells, and new-formation of connective tissue to such an extent that the membrane is enlarged to several times its normal thickness. The increase of bulk of the mucous layer, especially in cases of chronic suppuration in the middle ear, leads to adhesion of the membrane to the inner wall of the tympanic cavity, or without adhesion to thickening and opacity of the membrana tympani. In several preparations I found only the fibrous framework of the mucous layer (*vide* p. 19) hypertrophied and projecting in the form of a ridge above the level of the inner surface of the membrane. In addition, and especially in perforating inflammations, there may be developed in circumscribed parts, papillary excrescences, polypoid growths, pedunculated cysts of microscopic size, and also diffused and circumscribed whitish or pigmented deposits, which latter undergo calcareous metamorphosis.*

According to Schwartze,† in children with miliary tuberculosis, tubercles in the membrana tympani appear as yellowish-red spots of the size of a pin-head, or larger, in the intermediate zone. Seen from the tympanic cavity, these spots, slightly convex and distinctly circumscribed, appear prominently above the level of the mucous membrane.

Baratoux (*Bulletin et Mem. de la Société Otolog.*, t. ii., 2) observed in a case of syphilis, besides several small gummata on the face and auricle, a small opalescent gumma on the membrana tympani behind the malleus, which broke down later. Kirschner saw a syphilitic ulcer on the membrana tympani.

The anomalies in transparency and colour, the disturbances in the continuity, and the methods of healing of the perforations of the membrana tympani and its anomalies of curvature, will be discussed in detail in the description of the different forms of disease of the middle ear in which these changes of the membrane develop.

Inflammation of the Membrana Tympani.

I. *Primary Acute Inflammation of the Membrana Tympani (Myringitis Acuta).*

Acute inflammation of the membrana tympani affects this structure in its whole extent, or in part only. The signs of the inflammation are generally most marked in the posterior part of the membrane; only rarely does the immediately adjoining portion of the superior wall of the meatus participate in the affection. The

* Lucae found in a case of chronic catarrh of the middle ear carbonate of lime crystals in the thickened epidermis of the mucous layer.

† *Handbuch der path. Anat.*, v. E. Klebs, 1878.

cause of primary myringitis cannot always be discovered. That myringitis can be produced by pathogenic microbes has been proved by recent investigation; occasionally it develops after the action of cold wind upon the ear; after cold baths and douches; after sea-bathing (de Rossi) and frequently in children during the course of an acute naso-pharyngeal catarrh. The inflammation of the membrana tympani produced by scalds, instillation of irritating or cauterizing substances (chloroform, acids, etc.), or by mycotic growths, are generally combined with otitis externa.

Appearance of the Membrana Tympani.—Acute myringitis com-

FIG. 98.—A BLISTER OF THE SIZE OF A HEMP-SEED IN FRONT OF THE UMBO. FROM A MAN, 24 YEARS OF AGE, WHO FOR 2 DAYS HAD HAD AN INFLAMMATION OF THE MEMBRANA TYMPANI. ON THE THIRD DAY OF THE DISEASE THE BLISTER DISAPPEARED, THE DIM MEMBRANA TYMPANI WAS COVERED HERE AND THERE WITH BLACK ECCHYMOTIC SPOTS; ON THE FOURTH DAY THE POWER OF HEARING, WHICH WAS ONLY SLIGHTLY LESSENED DURING THE EXISTENCE OF THE BLISTER, WAS AGAIN COMPLETELY NORMAL.

FIG. 99. — TRANSPARENT PEARLY BLISTER IN THE POSTERIOR INFERIOR QUADRANT OF THE MEMBRANA TYMPANI OF A YOUNG MAN, WHO HAD AN INFLAMMATION FOR 18 HOURS. HEARING-DISTANCE ONLY SLIGHTLY DECREASED. ON THE NEXT DAY THE BLISTER HAD DISAPPEARED.

FIG. 100. — DARK-RED HÆMORRHAGIC BLISTER UPON THE POSTERIOR FOLD OF THE MEMBRANA TYMPANI OF A MAN 60 YEARS OF AGE, WHO SUFFERED FROM INFLAMMATION FOR 24 HOURS. ON THE THIRD DAY A DRY ECCHYMOSIS WAS VISIBLE ON THE SITE OF THE BLISTER.

mences with great hyperæmia of the external layer of the membrane, generally followed in a very short time by effusion into its tissue.

In the slighter degrees of myringitis, situated in the superficial strata of the dermic layer, there occurs associated with a redness of the osseous meatus, a diffuse vascular injection covering the handle of the malleus and a serous infiltration of this layer along with scattered, irregular ecchymoses; or one or more transparent blisters of the size of a hemp-seed, filled with serous fluid, are formed, the lustre and transparency of which give them the appear-

ance of fine mother-of-pearl (myringitis bullosa) (Figs. 98 and 99). The occurrence of hæmorrhagic blisters on the membrane is most frequently seen in influenza otitis. In a case observed by me (Fig. 100), the dark-red, oval blister was situated upon the posterior fold of the membrane. In another case the dark-red tumour occupied the whole posterior superior segment of the membrane.'

These blisters last only a short time as a rule, and frequently burst a few hours after they have risen; or they disappear again by rapid reabsorption of their contents. In the former case, a small quantity of watery or sanious fluid flows from the external meatus for a short time, and the next day, at the place where

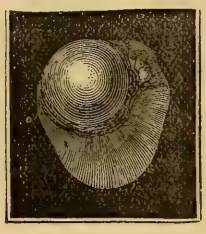

FIG. 101. — TENSE, YELLOWISH, TRANSPARENT, LUSTROUS BLISTER, INVOLVING THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANA TYMPANI. FROM A MAN 21 YEARS OF AGE, WHO HAD MYRINGITIS FOR 36 HOURS. TWO DAYS AFTER THE FIRST OBSERVATION THE BLISTER HAD DISAPPEARED WITHOUT HAVING BURST. THE HEARING-DISTANCE, WHICH HAD BEEN SLIGHTLY LESSENED, WAS AGAIN NORMAL AFTER A SHORT TIME.

FIG. 102.—BLISTER AND ABSCESS ON THE RIGHT MEMBRANA TYMPANI OF A YOUNG MAN, WHO HAD HAD AN INFLAMMATION OF THE MEMBRANE FOR 24 HOURS.

the blister was visible, the membrana tympani will be found to be covered by a layer of cracked epidermis, pale-gray in colour, the hyperæmia at and along the handle of the malleus will be decreased, and small ecchymotic spots will be seen near the point where the blister had been.

In the more severe forms of inflammation, blisters of considerable size, and abscesses which have their seat in the deeper strata of the dermic layer, will be formed. They occur sometimes singly and sometimes in groups of several, and may, according to the observations of Wilde, v. Tröltsch, Schwartze, Boeck (*A. f. O.*, vol. ii.) and the author, either be reabsorbed or empty into the meatus.

When inspecting the membrana tympani in such cases, there may be observed a swelling the size of a small pea, extending

over the posterior superior portion of the membrane, the appearance of which depends on the character of the exudation, and on its situation. In the case of serous exudation the swelling (Fig. 101) is like a large transparent pearl of a yellowish lustre; in the case of a purulent effusion, it is like a lustrous, non-transparent, yellowish-green blister; and if a more diffuse exudation takes place in the deeper strata of the dermic layer, the latter will be bulged forward in the form of a bluish-red lustrous tumour, or as a tumour covered with a slightly torn and sodden epidermic layer, which at first sight is very like a polypoid growth.

In the primary abscesses which I have observed, and also in the case of large blisters, the posterior superior quadrant of the membrana tympani was the seat of the affection; only once did I see small abscesses on the posterior inferior quadrant, and once on the anterior half of the membrane. They appear as semi-globular, pus-green, lustrous, but non-transparent tumours, or as small, pointed, greenish prominences, with a livid, sodden, or ecchymosed base, and a small drop of pus will ooze out on their being opened with a needle.

The blisters and abscesses which arise in the posterior superior portion of the field of view usually spread over a great portion of it, so that not only the handle of the malleus, but also the anterior portion of the membrana tympani, are over-arched and covered by them. The short process of the malleus generally remains visible as a white knob in front of and above the swelling, with an intensely red, ecchymosed base, not unlike a pustule surrounded by an areola. The simultaneous occurrence of blisters and abscesses is rare. In one case I observed on an inflamed membrana tympani a blister and an abscess beside each other (Fig. 102), of which the first disappeared on the third and the latter on the fourth day after the inflammation began.

Symptoms.—Acute myringitis, especially at its onset, is accompanied by violent stinging, piercing pain, radiating towards the parietal bone and the lateral region of the neck, sometimes also by subjective noises and pulsation. In a superficial inflammation, the pain generally lasts only a short time, and ceases when the blisters appear on the membrana tympani. If, however, exudation takes place in the deeper layers of the membrane, and the latter is bulged forward towards the meatus as a bluish-red swelling, or if an abscess is formed, the pain, especially by night, will be very severe, and will often last for several days without intermission, until the inflammation subsides. The formation of painless acute abscesses in primary myringitis is rare (Boeck). A feeling of fulness in the ear,

of pressure and of uneasiness, is occasionally complained of, and there is often great hyperæsthesia in regard to noises. Slight pyrexia occurs generally in children, seldom in adults.

The functional disturbance accompanying myringitis is not proportionate to the changes in the membrane. For if the hearing is tested at the stage when the symptoms of the exudation are most pronounced, generally only a moderate decrease in the acuteness of hearing for the tone of the acoumeter and for whispered speech will be found. The power of hearing is rarely much affected in inflammations of the membrana tympani, which by their future progress are proved to be of a primary nature.

Course. — The course of acute myringitis confined to the membrane, and causing no considerable swelling and exudation in the middle ear, is distinguished from that of acute otitis media by the more rapid decrease in the inflammatory phenomena, and by the much shorter duration of the process. The complete return of these cases to the normal occurs usually in 3 to 4 days; protracted, frequently relapsing cases are rare. The effused exudation is either rapidly reabsorbed, or is discharged into the meatus by bursting of the epidermic layer. In the latter case, the place where the blister was situated is covered by a gray, macerated epidermic layer, the vessels of the malleus are injected, and the base of the blister is sometimes ecchymosed. After the blister has burst, a slight decrease in the power of hearing is generally observed, caused by the inflammatory swelling, which has extended into the cavum tympani from the membrane. Bursting of the abscess inwards is very rare. In one case I was led to believe that this had occurred from the rapid disappearance of the abscess with a consequent rapid decrease in the hearing-distance, and from the sudden bulging outward of the collapsed swelling after the air douche. The communication of the tympanum with the cavity o the abscess was placed beyond doubt through the sharp definition of the exudation from the inflated air.*

Diagnosis.—The diagnosis of primary myringitis is only possible during the first days of the disease, when the appearance of the membrana tympani is not in proportion to the degree of functional disturbance, *i.e.*, when, in spite of the striking changes on the membrane, the hearing-distance is not noticeably decreased. A mistake is only possible in cases of acute otitis media, in which the inflammatory appearances on the membrana tympani are similar to those of acute myringitis. In the otitis media acuta a copious

* Compare my treatise, *Ueber Blasenbildung und Exsudatsäcke im Trommelfelle*, *W. m. W.*, 1872.

exudation occurs into the cavum tympani in such a short time that this, together with the accompanying swelling of mucous membrane of the cavum tympani and Eustachian tube will affect the hearing to a much greater degree. The diagnosis is difficult at a later stage if the inflammatory process extends to the cavum tympani and Eustachian tube, in which case it is not possible to ascertain whether the inflammation began originally in the membrana tympani or middle ear.

Results.—The end of acute myringitis is in most cases recovery; only rarely does chronic inflammation and suppuration on the external surface of the membrane develop, which occasionally go on to ulceration and perforation of the membrana tympani. More often an inflammatory swelling of the lining of the middle ear follows, which, however, subsides in a short time. After the cure of the myringitis, slight hyperæmia, radiating vascular injection, and opacity of the membrana tympani with continuous shedding of the epidermic layer (myringitis sicca, de Rossi), may continue for some time longer. The persistent changes which may remain on the membrana tympani are streaky, gray opacities, more rarely circumscribed calcareous spots or atrophied cicatricial-like thinnings of the tissue of the membrane.

Treatment.—The treatment of acute inflammation of the membrana tympani during the stage of reaction is palliative, and in the beginning of the process is not different from that of acute inflammation of the middle ear. We therefore refer the reader, as regards the application of local bleeding, narcotic embrocations, and other remedies recommended for the removal of pain, to the special section of this book. In those cases in which the formation of a yellowish-green abscess in the membrana tympani, accompanied by continuous violent pain, is observed, the abscess must be opened with a lancet,* so that the pus may discharge outwards. This operation, which is a very easy one, is advisable in the case of abscesses of the membrana tympani, situated in its deeper layers, because it prevents the pus from penetrating towards the tympanic cavity. But in the case of globular blisters of a pearly-gray lustre, transparent, and filled with serous fluid, especially if they are observed after the pain has ceased, the artificial opening is unnecessary, because, according to my experience, these blisters either quickly subside, or burst spontaneously very soon after they have risen, and discharge their contents into the external meatus. In inflammations in the deeper layers of the membrana tympani,

* The details of the operation of paracentesis of the membrana tympani will be given in the section on 'Treatment of Sero-mucous Middle-ear Catarrh.'

in which the membrane appears bulged forward in the form of a bluish-red swelling, incisions with the lancet, or with a narrow knife like a tenotomy-knife, are advisable only in those cases in which, on account of violent pain, a diminution of tension in the infiltrated portions of the membrane is rendered necessary. In this instance, as well as when opening abscesses, care must be taken that not more than one half of the lancet is inserted into the membrana tympani, because all the layers of the membrane will be severed if the lancet penetrates more deeply, and so the inflammation will spread to the tympanic cavity, and suppuration will be set up, by which the otherwise rapid cure might be postponed for a long time. After the incision the edges of the wound generally close within a short time; only rarely does a protracted collection of pus remain on the membrane.

The use of the air douche in acute myringitis is only indicated in those cases where a rapid decrease in the hearing-power takes place, after the pain has disappeared, from which an additional swelling and secretion in the middle ear may be inferred. The method of the author is generally used and should be continued once a day until the deafness disappears. In the rare forms of myringitis with pustular exudation on the membrane it is sufficient for stopping the secretion to wash out the meatus several times with a 1 to 2 per cent. solution of Lysol, followed by the insufflation of finely-powdered boric acid.*

II. *Chronic Inflammation of the Membrana Tympani* (*Myringitis Chronica*).

Etiology.—Chronic inflammation of the membrana tympani, in which the inflammation is confined to the membrane alone, is among the rare diseases of the ear. It occurs as the result of primary acute myringitis, generally after an inflammation of the whole dermic layer, which has been followed, especially in scrofulous and cachectic people, by continued suppuration on the external surface of the membrane. Sometimes it occurs insidiously, without previous reactive phenomena. More frequently, however, chronic myringitis is a sequela of a previous otitis externa, after the changes produced by the inflammation on the walls of the meatus have disappeared. I have also seen the signs of a chronic inflammation remain in the membrana tympani after the cessation of suppuration

* For Myringitis crouposa, refer to the portion 'Otitis Externa Crouposa and Diphtheritica' (p. 181).

in the middle ear, and after the closure of the perforation in the membrane.

Chronic myringitis usually affects the whole surface of the membrane; sometimes, however, it is limited, most frequently to the posterior superior portion, and next in frequency to the region of Shrapnell's membrane. The last-named forms are, however, but rarely confined to the membrane; generally a limited portion of the posterior or superior wall of the osseous meatus, immediately adjoining, is involved.

The Appearance of the Membrana Tympani.—In the slighter degrees of diffuse inflammation the membrane appears of a moist lustre covered with secretion, and of a gray colour with faint yellowish-white spots; the red vascular bundle of the handle of the malleus and the short process can still be plainly seen through the thin layer of secretion. In the case of proliferation and thickening of the epidermic layer, however, the membrane is covered by a whitish-yellow, non-transparent layer, which hides the malleus, and which can only with difficulty be detached from its base by syringing. If in such cases there is a great desquamation of the dermic layer, after peeling off of the epidermis the membrane appears intensely congested, flattened, velvety, with irregular reflections of light scattered over it; and when the epidermic layer is partially detached, the congested places, deprived of their external layer, may be mistaken for ulcers on the membrana tympani.

FIG. 103.—GRANULATIONS ON THE MEMBRANA TYMPANI OF A YOUNG GIRL, WHO SUFFERED FOR SEVERAL YEARS FROM DISCHARGE FROM THE EAR; REMOVAL OF THE GROWTHS BY TOUCHING THEM WITH LIQ. FERRI SESQUICHLOR.

Chronic myringitis leads in some rare cases to the formation of papillary excrescences (*vide* p. 229). They appear as light-red papillæ the size of a pin-head, singly or in groups (Fig. 103), or in greater numbers spread over the whole surface of the membrane. In the latter cases the membrane has the appearance of a purple raspberry with numerous dots of light sprinkled over it. In one case an isolated growth occurred exactly at the point of the short process; in another, above it upon Shrapnell's membrane. Occasionally the papillary formation extends over from the posterior superior quadrant of the membrana tympani upon the posterior superior wall of the osseous meatus.

Diagnosis.—The changes produced by condensation of air in the tympanic cavity, as seen during inspection, are important in the

diagnosis of primary chronic myringitis. Upon employing the Valsalvan experiment, or my method, the membrane plainly becomes curved outwards, without air passing through it into the meatus. By this means chronic myringitis is differentiated from chronic suppurative inflammations of the middle ear accompanied by inflammation of the membrana tympani. This fact, however, must not be considered as pathognomonic of chronic myringitis at the first examination, because, as we shall see later on, in chronic perforating suppuration of the middle ear a temporary closure of the margins of the perforation may take place. However, it should be mentioned, that along with chronic swelling and secretion in the middle ear without perforation of the membrane, there may exist a chronic secretion on its external surface.

Symptoms.—Chronic myringitis either runs a quite painless course, or is only now and then accompanied by fleeting, lancinating pains in the ear. Subjective noises are on the whole rare, and generally intermittent; and equally seldom is the feeling of fulness and pressure in the ear complained of. The most troublesome symptoms, which are frequently the sole reason for the patient's applying for surgical treatment, are the severe itching and the offensive smell from the ear, caused by decomposition of the cerumen mixed with pus.

Results.—The results of the inflammation, which often lasts for years, are either complete recovery, when the secretion ceases; or it may terminate in a moderate thickening of the membrana tympani with a trifling disturbance of the hearing. Rarely does it go on to the formation of superficial or perforating ulcers. Excessive thickenings of the membrane, as described by v. Tröltsch and de Rossi, I have not observed. After the secretion has ceased, a great desquamation of the epidermic layer (myringitis desquamativa, Gottstein) or incrustation on the membrana tympani sometimes goes on for a considerable time. In myringitis granulosa suppuration is maintained by the papillæ which are developed, and a cure will result only after their spontaneous healing or after their removal by surgical treatment.

Treatment.—The treatment of chronic myringitis depends on the changes that have occurred in the membrana tympani. If the secretion is accompanied by a slight desquamation of the dermic layer only, the accumulation will generally be stopped by washing out several times with an antiseptic solution (Lysol, carbolic or resorcin solution) and following with the insufflation of powdered boric acid. If no decrease of the suppuration takes place after using the boric acid for several days, then one should

use an alcoholic solution of boric acid (1 in 20), or a solution of carbolic acid in alcohol (1 in 30), of which 15-20 drops of the warm solution should be dropped in the ear and left for half an hour. When it produces severe burning it should be diluted with one-third water.

The use of astringents as formerly practised (sulphate of zinc and sacch. saturni 0·2, aqua. dest. 20·0) is now only resorted to when the antiseptic treatment fails. In specially obstinate cases the concentrated solution of silver nitrate (nitr. argent. cryst. 0·8, aqua. dest. 10·0) has proved very serviceable. After each application the solution is to be neutralized by washing out with a salt solution. The instillation should only be repeated when the cauterized portion has been thrown off, and three applications a week, for the space of three or four weeks, is generally sufficient to stop the accumulation on the membrana tympani. The desquamative forms are the most persistent. Repeated instillation of alcohol is less efficient than the nitrate of silver solution. Ulcerations often heal very rapidly after the insufflation of iodoform or iodol powder, the touching of the surface of the ulcer being seldom necessary.

If granular formations have taken place on the membrana tympani it is advisable to destroy them by means of liq. ferr. perchlor., either by applying the remedy to the growths in small drops by means of a probe dipped into the fluid, or by painting them with a small hair or cotton brush. These cauterizations are to be continued until the membrana tympani is smooth and dry.

Cauterization with chloride of iron is decidedly to be preferred to that with nitrate of silver or chromic acid, on account of the more rapid destruction of the growths, and because it produces less pain. On the other hand, cauterizing with the galvano-cautery is preferable to all other methods on account of the smaller amount of pain it produces and the shorter time in which healing is brought about. When applying the galvano-cautery, a simple platinum point should be used; the circuit must be closed only when the point of the electrode touches the growth; each cauterization, applied at one sitting in 5-6 different parts of the membrane, must last only 2-3 seconds; the electrode must be removed immediately after every cauterization, and the hot vapours, developed in the meatus, may be removed by blowing into it. Cocaine solutions (2-5 per cent.) are only of use when there is long-continued pain in the ear.

Traumatic Lesions of the Membrana Tympani.

The traumatic injuries of the membrana tympani are produced: (1) by direct penetration of a foreign body into the membrana

tympani; (2) by the extension of a fracture of the cranial bones to the membrane; and (3) by a sudden condensation of air in the external meatus or in the tympanic cavity, more rarely by a rapid rarefaction of the external air.

(1) The direct injuries of the membrane occur for the most part in persons who scratch the meatus with different objects on account of an unpleasant itching, and by an accidental push pierce the membrane with the instrument employed, such as ear-picks, hair-pins, tooth-picks, matches, pieces of straw, pencils, etc. They may also be caused by the careless manipulation of syringes with long, pointed nozzles, by coarse attempts at extraction of foreign bodies, by splinters of wood flying into the meatus, or by thorns entering the meatus while passing through a thicket. From within a strongly retracted membrana tympani may be penetrated by a bougie introduced into the cavum tympani.

The site, the size, and the form of these injuries are very various, depending, according to Zaufal's experiments on the dead body (*A. f. O.*, vol. viii.), on the more or less marked spiral twisting of the meatus; farther, on the character of the instrument, whether its penetrating end is sharp, blunt, pointed, rigid or flexible, smooth or rough, and also on the force with which it was introduced. The rupture from direct penetration takes place more frequently in the posterior than in the anterior half of the membrane.

The appearance of the membrane varies according to the extent of the destruction, and the time at which the inspection of it is made. Shortly after an injury with a thin, pointed instrument, one finds openings more or less round in shape, the margins and surroundings of which are covered with blackish-red extravasated blood. In the case of extensive, irregular ruptures, the shape of the gap is not recognisable, on account of the extravasated blood covering the membrane. But when suppuration commences, and the extravasations are removed by syringing, it is sometimes possible to see the extent of the destruction.

At the moment of the occurrence of the injury, a loud report is heard, and a piercing pain is felt, followed either by fainting, or by reeling, giddiness, and great tinnitus. After several hours relief will take place, but the numbness of the head and the subjective noises will still continue for a considerable time. At the commencement of the reactive inflammation, the pain and the noises will again increase in intensity, and the latter especially continue long after the subsidence of the inflammation and the suppuration. In a case observed by Delstanche, of a young girl who had injured the membrana tympani with a knitting-needle two years before,

there was complete deafness, intolerable tinnitus, and severe attacks of dizziness. There was an adherent cicatrix visible on the posterior superior quadrant of the membrane.

The injuries produced by direct action are rarely cured without inflammation and suppuration. In cases of extensive, irregular ruptures especially, but sometimes also in cases of smaller perforations, a painful suppuration of the middle ear occurs, which lasts for weeks and months, and in consequence of which inflammations in the mastoid process and in the external meatus may develop. After the subsidence of the suppuration, permanent gaps or cicatricial formations not unfrequently remain in the membrana tympani, which often adhere to the inner wall of the tympanic cavity, generally causing severe permanent deafness. In regard to the treatment to be employed here, reference must be made to the treatment of the acute and perforating inflammations of the middle ear.

(2) In the case of ruptures of the membrane, caused by the extension of a fracture of the cranial bones, the membrane generally presents a fissure of more or less extent stretching from the superior or anterior wall of the meatus. The copious bleeding from the ear which usually takes place is due to the vessels, partly of the membrana tympani, and partly of the diploe of the fractured bones. In such cases the rupture of the membrane is of less significance than the injury to the cranium. If death does not ensue, profuse suppuration, proliferation of the inflamed membrana tympani, and of the mucous membrane of the middle ear, and adhesion of the remains of the membrana tympani to the inner wall of the tympanum will take place.

(3) We will now describe ruptures of the membrana tympani, caused by sudden condensation or rarefaction of air in the external meatus. These are due mostly to blows or falls upon the ear, or to explosions in its near neighbourhood; as, for example, the report of a cannon (Orne Green, Bonnafont), and from intense shocks to the membrana tympani from a stroke of lightning (Ludewig). Rupture of the membrane is favoured by obstruction in the Eustachian tube, which does not allow of the escape of the air condensed in the cavum tympani; farther by atrophy, cicatricial formation and deposits of chalk in the membrana tympani. Ruptures due to rarefaction of air in the external meatus (kiss upon the ear, aeronauts, therapeutic rarefaction of air) are very rare. Tears of the cuticular or mucous layers of the membrane alone are seldom seen. As the ruptures of the membrane, caused by a blow upon the region of the ear, claim the interest of the practitioner from a

forensic point of view, it seems important to discuss these first in detail.

At the moment of the occurrence of the blow, and of the resulting injury, many perceive a violent report in the ear, others a great pain. The patient is further frequently seized with staggering, giddiness, and great tinnitus, so that he is unable to stand upright. The latter symptoms decrease in intensity after a few hours, but often a feeling of stupor remains for several days, and in some cases tinnitus continues for a long time.

The objective examination of the membrana tympani is of the greatest importance. The appearance of the membrane is so characteristic in the first days after the injury, that we are enabled

FIG. 104.—RUPTURE IN THE ANTERIOR INFERIOR HALF OF THE MEMBRANE OF A BOY AFTER A BOX ON THE EAR.

FIG. 105.—DOUBLE RUPTURE OF THE MEMBRANE OF A WOMAN, 30 YEARS OF AGE, CAUSED BY A FALL UPON THE EAR; APPEARANCE ON THE THIRD DAY AFTER IT HAD TAKEN PLACE.

FIG. 106.—ROUND RUPTURE IN THE ANTERIOR SUPERIOR QUADRANT OF THE MEMBRANE OF A GIRL, WHICH WAS CAUSED BY A LARGE BOX FALLING UPON HER EAR.

to ascertain from it whether the perforation in the membrane is caused by an injury or by a pathological process.

The assertion has been made that, in the case of injuries of the membrana tympani caused by sudden condensation of air, the rupture appears as a linear gap (Toynbee), which extends behind or below the handle of the malleus, and the margins of which are applied to each other, and are only forced asunder by the Valsalvan experiment, or in the form of the letter T, as Hubert-Valleroux avers. According to my observations, this form seems to be a rare one, for in the cases seen by me, the rupture presented always a gaping orifice, or a hole, through which the inner wall of the tympanic cavity could be plainly seen.

The situation of the rupture in the membrane is more frequent in the posterior portion of the membrane. There is generally only one, seldom two ruptures, in the membrane (Fig. 105). The perforation is generally situated midway between the handle and the

tendinous ring; only rarely does it extend from close in front of the handle of the malleus to the tendinous ring.

The shape of the rupture may be round (Fig. 106), as if a piece of the membrane had been punched out, but it is generally oblong, oval, with pointed (Figs. 104 and 105) or rounded extremities, and the longitudinal axis of the oval is parallel with the direction of the radiating fibres. More rarely linear tears in front and behind the handle of the malleus, which do not separate, or irregular ragged ruptures occur. In one of my cases the bloody edges of a ragged rupture were so much retracted towards the periphery and handle of the hammer that a large portion of the promontory was visible.

The margins of the rupture are sharply defined, and are covered, either in their whole extent or only here and there, with reddish-black coagulated blood. Sometimes ecchymosed spots will be found near the rupture (Fig. 106), especially at the posterior margin of the handle, and marked congestion of the vessels along the malleus. The inner wall of the tympanic cavity will be seen as a bone-yellow surface of a moist lustre, without noticeable vascular injection.

Another symptom, important in deciding whether a traumatic rupture of the membrane has taken place, is the auscultation sound of the air rushing through the orifice of the rupture when the Valsalvan method is being performed. For while in the case of perforations produced by diseases of the middle ear the air, pressing through the Eustachian tube into that cavity, escapes from the ear with a sharp, hissing noise, even when there has been great loss of substance, the air rushes from the ear with a very broad, deep, breathing-sound in cases of traumatic rupture of the membrane, if the injury has befallen a normal ear. It will further be observed that a much less considerable amount of exertion is required to press air through the tube into the middle ear in the latter cases.

The degree of the disturbance of hearing caused by traumatic ruptures is usually slight. Severe deafness only occurs when, besides the rupture, there has also been concussion of the labyrinth. The sudden condensation of air in the external meatus may have two different effects.

If the force of the blow is exhausted on the membrana tympani, tearing its elastic fibres, the labyrinth as a rule remains intact. The power of hearing is in these cases generally but slightly lessened, for speech and the acoumeter, and the tone of a tuning-fork placed upon the vertex is localized in the injured ear.

If, however, the membrane remains intact, the force of the condensation of air produced by the blow is not exhausted at the

membrana tympani, but causes a concussion and paralysis of the expansion of the auditory nerve in the labyrinth, by suddenly propelling the ossicular chain inwards. In these very unfavourable prognostic cases (according to my observation with positive Rinne), the tone of the tuning-fork from the vertex is almost always localized in the normal ear.

The course of ruptures of the membrana tympani, not complicated with concussion of the labyrinth, is, as a rule, a favourable one, as the gaping orifice in the membrane is closed again without any marked phenomena. The cicatrization of the rupture often takes place from the mucous membrane, as is shown by the examination. A grayish-yellow pellicle is pushed from within outward, which may be seen for a long time, while the torn edges of the cutis remain separated. It is only rarely that a diminution of the rupture takes place from an equal growth of the epidermis (Rummler), or by simultaneous growth of all the layers of the membrane.

The coagulated blood adhering to the margins of the rupture either falls off or migrates from the centre towards the periphery of the membrane, and is pushed into the osseous meatus. It is only after several weeks that the membrana tympani presents its normal appearance; only rarely a thin cicatrix remains on the ruptured spot.

A rare consequence of traumatic ruptures of the membrana tympani is the development of inflammation of the membrane and of the lining membrane of the middle ear with suppuration (Hassenstein). The cause of this inflammation is generally from instillation of irritating oils or other medicated solutions. The result of such consecutive suppuration is rarely complete healing. More often it goes on to destruction of the tissue of the membrane, to the formation of granulations on the membrane and in the cavum tympani, to adhesions between the membrana tympani and the promontory (Burnett), and to covering of the edges of the perforation with epidermis, leaving a persistent opening (Roosa).

In most cases, disturbances of hearing caused by traumatic ruptures disappear completely, so that the function becomes normal again. It is only in those cases in which permanent changes in the middle ear are developed in consequence of suppuration having taken place, or in which the rupture of the membrane is combined with concussion of the labyrinth, that disturbances of hearing of different degrees, headache and tinnitus, remain. In those cases also in which by a blow upon the region of the ear, a concussion of the labyrinth has been produced, without an injury to the

membrane, and associated with tinnitus and hardness of hearing, the function of hearing may again become quite normal after several days or weeks; more frequently, however, a disturbance in the hearing will remain for life.

In the treatment of ruptures of the membrane I consider it best to avoid all local applications, as by instillations of medicated solutions, syringing or the air douche, the cure is not only not promoted, but even retarded. But when in the open air, especially during damp and cold weather, the patient must close the meatus with cotton wool to protect the exposed mucous lining of the tympanic cavity from atmospheric influences. In cases of concussion of the labyrinth the application of a constant electric current causes an improvement in the hearing-distance and a decrease of the subjective noises.

The Traumatic Ruptures of the Membrana Tympani from a Forensic point of view.—If a surgeon is asked to state whether a rupture is of a traumatic nature, it is necessary above all that the patient be examined during the first few days after the injury has taken place; for if the examination take place only a considerable time after the infliction of the injury, the surgeon, owing to cicatrization of the rupture, may not be able to ascertain whether rupture has taken place at all, and whether the existing functional disturbance has really been produced by an injury.

A medical jurist cannot say that a case is of traumatic origin if at the time of his first examination a suppurative inflammatory process has already taken place in the membrana tympani and in the middle ear, as the appearance of the membrane in such a case is not distinguishable from that in a primary suppurative process of the middle ear. He will therefore be justified in concluding a rupture of the membrane to be traumatic only if, after having discovered the almost characteristic appearance of the membrana tympani above described, cicatrization of the rupture take place in the space of several weeks under his observation. The latter is of special importance, because a persistent gap, produced by a previous purulent process, may be present, and might be mistaken, on account of the sharp definitions of its margins and of the other appearance of the membrane, for a traumatic rupture. Such a mistake will not, however, occur if the surgeon bear in mind that a gap caused by a previous suppuration, as soon as its margins are healed over, will not be closed at all. Traumatic ruptures, however, according to my observations, have only two results: either cicatrization takes place during the first weeks or suppurative inflammation occurs.

If the traumatic nature of the affection of the membrana tympani has been ascertained by the surgeon, another question will have to be answered, viz., whether the injury is to be considered as slight or severe.

An injury of the membrana tympani is to be called a slight one if it is not complicated with concussion of the labyrinth, and if, after cicatrization of the rupture, apart from the duration of the process of cicatrization, the function of hearing returns to its normal state.

An injury of the membrana tympani must, however, be considered as severe if by a blow upon the ear concussion of the labyrinth has taken place. For the diagnosis of paralysis of the auditory nerve the general result of testing of hearing should be taken into consideration, especially great deafness for the acoumeter, watch, and speech, the lateralization of the tone of the tuning-fork in the non-affected ear when placed on the vertex and positive Rinne. It should be specially understood that the results of testing should only be used by the medical jurist for judgment when repeated examinations have been made, so as to completely exclude simulation (*vide* the section on 'Simulation').

An injury of the membrana tympani will also be a severe one if, a traumatic rupture having been ascertained, it is aggravated by suppuration; and changes in the middle ear (adhesions, granulations) are produced by it which cause a permanent disturbance in the hearing.

This will show that the medical jurist is not always able on his first examination to form a judgment as to the character of an injury, but that in a number of cases a lengthened observation, extending over at least three months, is required; for concussion of the labyrinth may exist after an injury of the ear, the consequences of which will not permanently remain, as the function of hearing sometimes becomes normal again after two or three months. In the same manner a suppurative process, which aggravates a rupture of the membrane, may end without leaving any changes in the middle ear.

In the case of functional disturbances, produced by a blow upon the region of the ear, and caused by concussion of the labyrinth without any injury to the membrana tympani, the surgeon cannot form an opinion as to whether, in a given case, the disturbance of hearing was caused by an injury or not, as the objective appearance of the membrana tympani and other characteristic indications are wanting as data. The surgeon must therefore in such cases always bear in mind the possibility of the existence of a chronic affection of the labyrinth or of the middle ear, which the alleged injured person may make use of to sue his opponent after a quarrel. If, however, the surgeon finds, shortly after the alleged injury is supposed to have taken place, calcification and cicatricial formations on the membrana tympani, he may conclude with certainty that it is a chronic process in the middle ear, because changes of this kind cannot develop in a few days, but require a considerable time.

Paragraph 156 of the Austrian Penal Code, which enumerates the permanent consequences of injuries, the presence of which entails the highest measure of punishment (hard labour for five to ten years), includes the loss or the lasting defect of the hearing-power among 'aggravating circumstances.' E. Hoffmann* makes the following remarks about this: 'Although it cannot be doubted that the loss or a great disturbance of hearing on one side causes a decrease in the power of hearing, the same importance cannot be ascribed to such a loss as to the loss of the power of vision in one eye. The legislator clearly thought of the sense as a whole, and in the new (Austrian) draft, as well as in the German Penal Code, hearing in general is

* *Lehrbuch der greichtlichen Medicin*, Wien, 1878.

only spoken of, but no difference is made between the hearing in one or both ears, as was done regarding the power of vision. We must also bear in mind that it is only a considerable disturbance of hearing, which may be set down as a defect of the hearing in the sense of the law, and it is advisable, just as in the case of weakness of vision, that we should confine ourselves in doubtful cases only to the explanation of the nature and of the degree of the functional disturbance, and leave it to the judge and to the jury to say whether after such an explanation they will recognise the case as coming under clause *a* of paragraph 156 or not.' To this argument I should like to add the remark that although the loss of hearing on one side causes no notable disturbance of hearing in ordinary intercourse, the fact should not be lost sight of, that according to experience, in cases of one-sided deafness, the sound ear becomes very frequently sympathetically affected, and that such an affection, as a rule, causes a rapidly increasing hardness of hearing.

In conclusion we will draw attention to the ruptures of the membrana tympani observed in those whose death was caused by hanging. According to the cases communicated by Wilde, Ogston, and Littré, ruptures seem more frequent in those who have been executed than in suicides. How the rupture occurs is not very clear, and I am myself in doubt about this matter. The fact that in the cases described by Ogston and Schwartze the torn patch of the membrane was turned outwards, would show that the mechanical force (excessive condensation of air) must have acted from the direction of the tympanic cavity.

According to the observations of Brigade Surgeon Chimani, during ten years (1867 to 1877) among 5,041 aural patients treated, 54 cases of rupture of the membrana tympani were observed. They were caused in 38 cases by boxes on the ear, in 6 cases by falls upon the head, in 3 cases by a kick from a horse on the head, in 2 cases by strokes upon the head with wooden clubs, in 2 cases by the playing of brass instruments (signal trumpet and helicon), in 2 cases by the report of a loaded gun in the immediate neighbourhood of the ear, and in 1 case by a fall into the water from a considerable height.

The ruptures caused by boxes on the ear were in 36 cases in the left and only twice in the right ear; the rupture was in 27 cases in the posterior inferior quadrant of the membrana tympani, in 9 cases in front of and somewhat below the extremity of the handle of the malleus, and twice in the superior posterior portion of the membrane, almost on a level with the short process. The rupture was never linear in form, but was generally ragged, roundish or oval. The bleeding was in no case so considerable as to be perceived by the patient. During the first days giddiness, tinnitus, and considerable functional disturbance generally took place. In 34 cases perfect recovery without any functional disturbance resulted; in 4 cases no complete cure was effected; indeed, in 2 of them, in which the patients had been repeatedly subjected to blows on the ear when the rupture already existed, and which came under treatment only on the 8th and 14th days respectively after the occurrence, a purulent inflammation of the middle ear, with perforation of the membrane and a superficial necrosis on the mastoid process, set in. The perforation extended over the posterior inferior and central portions, and could not be made to close by treatment.

The ruptures caused by falling upon the head were 4 times in the anterior inferior quadrant, once in the centre of the posterior portion of the membrana tympani, and once in the region of the short process of the malleus. The bleeding was in 3 cases so considerable that the patients had their attention drawn to the injury of the ear by the blood flowing from it. In 2 cases, in spite of the perforation being healed, a considerable hardness of hearing, and in one case a labyrinthine affection, remained.

The ruptures produced by the kick of a horse on the head were all in the right ear and the posterior inferior quadrant (flap-wounds); one case was accompanied by extravasation of blood on the membrane and on the lining membrane of the meatus. In all cases recovery without any functional disturbance took place after suppuration had ceased.

In the same manner the ruptures caused by blows upon the head, and by the report of a loaded gun, ended in cure by suppuration. In the one case in which the rupture of the membrane was produced by a fall into water from a considerable height (attempted suicide), the membrana tympani was torn in its whole extent. The injury, which healed up after a lengthened suppuration, left behind considerable functional disturbance.

The fact that formerly ruptures of the membrane frequently occurred in artillerymen, while they are now scarcely met with at all, may be explained by the fact that since the introduction of breechloaders the serving party withdraws a distance of about twelve paces, with the exception of one man who attends to the firing, but also from a considerable distance, by which means they are protected from the action of the most intense sound.

B. The Diseases of the Cavum Tympani, the Eustachian Tube and the Mastoid Process.

General Observations.

The pathologico-anatomical examination of the ear in the last ten years has given very important results. In the larger number of the cases of ear disease, the disturbance of function was found to have its seat in the middle ear, and the primary diseases of the auditory nerve apparatus are found to be much more rare. Among the diseases of the ear, the affections of the middle ear have for this reason the most interest for the practitioner.

The principal seat of the diseases of the middle ear is in its membranous lining. From here the inflammatory changes start, which not only often disturb the hearing, but also may extend to the neighbouring organs and menace the life of the patient.

The knowledge of these changes is therefore of great importance, as they form the basis for the diagnosis and treatment of middle-ear affections.

The inflammatory processes and their results on the lining of the middle ear show in general the character of inflammation of the

mucous membranes of other organs with this difference, that in the middle ear thickening of the tissues and adhesions of the diseased surfaces of the mucous membrane occur more frequently than in other organs. We find, therefore, in inflammations of the lining of the middle ear the changes which occur in other inflamed mucous membranes, as hyperæmia and serous infiltration, loosening and excessive swelling through exudation and infiltration of round cells; further, the secretion of free exudate from the surface of the diseased mucous membrane, in the form of serous, mucous, or pustular secretion; and lastly as secondary diseased products, organized connective tissue, which, in the course of inflammatory processes, occurs as thickening and proliferation of the mucous membrane, or strings of connective tissue in the middle ear.

The inflammatory processes in the middle ear show great variation, as well anatomically as from the clinical point of view. Their course is either acute, sub-acute or chronic, and they may heal with complete restoration of the normal hearing, or, by the production of permanent diseased products, may produce deafness to a varying degree.

It has been tried to gather the different forms of disease of the middle ear into definite classes, sometimes the etiological factors, sometimes the pathologico-anatomical conditions have been used as the basis for the classification. These classifications have proved unpractical, as, on the one side, analogous processes are produced by different causes, and on the other, with similar anatomical changes, the clinical aspect of the middle-ear inflammation may be quite different. In a similar way the anatomical examination, as well as clinical observation, contradict the views which have been advanced, that the different forms of the middle-ear inflammation are only successive steps in one inflammatory process. For while one form of inflammation may change into another, and show the different steps of development, it is positively proved clinically that certain inflammatory processes of the middle ear show a peculiarity in their beginning and entire course which gives them their typical character. These peculiarities are of great importance from the clinical aspect, as will be seen in the special descriptions of middle-ear affections, for, in many cases, through these alone the exact prognosis and the proper method of treatment can be determined.

From what has already been said, it will be seen that, according to the present state of our knowledge, a classification on a clinical basis seems to be the best. The description according to clinical types not only facilitates the survey of the many forms of inflammation, but also serves as a guide in every single case, as it supplies the practitioner with indications for diagnosis, prognosis, and treatment.

If we consider the inflammations of the middle ear in a general way, according to their leading clinical features, we meet in the first

instance principally with a great group called catarrhs of the middle ear, in which the inflammation, accompanied by hyperæmia and swelling of the mucous membrane, is characterized by the discharge of a serous, or of a tough, colloid mucous secretion. This form of inflammation of the mucous membrane generally runs its course without notable phenomena or lesion of the membrana tympani, and may either completely subside, or it may give rise to various changes, such as adhesions between the ossicula and the walls of the tympanic cavity, with permanent hearing disturbances taking place during its course, in consequence of the growth of connective tissue in the mucous membrane, and of the formation of bands of tissue.

Next in order to these adhesive processes following middle-ear catarrh, is a kindred inflammatory form, clinically different, however, in many respects, in which, without any demonstrable secretion, the ossicula, but most frequently the stapes, become fixed, owing to the gradual shrinking and induration of the mucous membrane (sclerosis) and of the ligamentous apparatus. I refer here to those insidious forms producing severe deafness which so frequently come under observation, the so-called 'dry catarrh.' They will be more fully described in the special portion.

Another group of inflammations of the middle ear includes those forms which develop with acute inflammatory phenomena, more or less violent and sudden effusion of a purulent or muco-purulent exudation, in which, as a rule, the membrana tympani is also affected by the inflammatory process. If we take a general survey of this group, we may say that the course of the affections comprised in it is such that either the inflammation quickly reaches its climax, and the whole process subsides after a short period without lesion of the membrana tympani (acute inflammation of the middle ear), or in still more severe forms perforation of the membrana tympani, with effusion of purulent or muco-purulent secretion (acute perforating or suppurative inflammation of the middle ear), takes place, in consequence of a copious effusion with ulceration of the membrana tympani. The latter form of inflammation may also subside after a short time with cicatrization of the perforation and restoration of hearing, or it may lead to chronic suppuration of the middle ear (chronic perforating or suppurative inflammation of the middle ear). This may also subside, but frequently causes permanent disturbances of hearing in consequence of ulceration of the membrana tympani, exfoliation of the ossicula, granulation and shrinking of the mucous membrane, with anchylosis of the ossicula; or it may even have a fatal issue by

extension of the suppuration to the cranial cavity and to the adjoining sinuses.

In consideration that the greater proportion of cases of disease extend over the whole of the cavum tympani and the Eustachian tube, and that diseases limited to the Eustachian tube are very rare, I consider it better for the general study of middle-ear diseases to describe them together than to separate them, as is done in other text-books.

These general observations should be noticed by the reader in order to understand the way in which middle-ear affections are described in this book. If this differs relatively from the forms generally used in otology, it is in the effort to limit certain forms of middle-ear inflammation more sharply in their clinical and practical significance.

As the terms 'catarrh' and 'inflammation of the mucous membrane' are synonymous, names like 'purulent catarrh of the middle ear,' or 'purulent inflammation of the middle ear,' can be used for the same purpose. For practical purposes, however, it would be advisable to call those forms which run their course without significant inflammatory phenomena, and with a discharge of sero-mucous exudation, 'catarrhs,' and those forms which are accompanied by violent inflammatory phenomena, by formation of muco-purulent or simply purulent secretion, 'inflammations.' Certain designations, as otitis media serosa, hæmorrhagica, crouposa, diphtheritica, etc., are in so far justifiable, as they indicate in a certain case some peculiarity of the process, a more distinct clinical definition of the disease being intended by it.

1. Catarrh of the Middle Ear

(*Otitis Media Catarrhalis*).

The inflammatory affections of the middle ear, which are clinically comprised in the appellation 'catarrhs of the middle ear,' are characterized anatomically by more or less pronounced hyperæmia, swelling and desquamation of the mucous membrane of the middle ear, and by the secretion of a clear, serous fluid, or of a viscid, sticky, mucous exudation into that cavity. They mostly run their course without marked active symptoms, and without disturbance of the continuity of the membrana tympani, and end in a cure by subsidence of the changes, or in the development of permanent inflammatory products, which lead to rigidity of the articulations of the ossicula, to abnormal adhesions, and to their fixation with permanent disturbance of hearing. From a practical point of view, especially in regard to the difference in the modes of treatment, I have considered it best to describe first the catarrhs which are accompanied by demonstrable secretion and swelling, and then those adhesive processes which either develop independently or as a sequel to the catarrhs with exudation.

(*a*) *The Secreting form of Middle-ear Catarrh.*

(*Syn.: Sero-mucous Middle-ear Catarrh.—Otitis Media Serosa.—Catarrh of the Cavum Tympani and Eustachian Tube.*)

Etiology.—The causes of the catarrhs of the middle ear with discharge of serous or mucous exudation are atmospheric influences, colds, influenza, the acute exanthemata and syphilis; but most frequently they are due to the extension of acute or chronic catarrhs from the naso-pharynx. The knowledge of the presence of pathogenic micro-organisms in the catarrhal secretion of the cavum tympani leads one to conclude that middle-ear catarrh often occurs through bacterial invasions from the naso-pharynx. Besides these, sero-mucous exudation is produced by paralysis of the muscles of the palate and tube, and after diphtheria, and, as I first observed, from pressure of new growths upon the canal of the tube. The exudation into the cavum tympani is caused in the first instance by the inflammatory process in mucous membrane, but the secretion of serous fluid is often produced by the rarefaction of air in the cavum tympani due to closure of the tube.

In the sero-mucous catarrhs the affection generally extends over the whole surface of the middle ear, yet in recent catarrhs which extend from the naso-pharynx, the swelling and hypersecretion may be limited to the lower portion of the Eustachian tube without extending to the cavum tympani. It is these cases which occur in the course of acute or chronic naso-pharyngeal catarrh. They are rarely primary, and are combined with an intumescence and hypersecretion of the ost. pharyng. tubæ, and may extend some distance into the canal of the tube. These peculiar catarrhs of the tube may heal without any disturbance of hearing, remaining as a local disease of the Eustachian canal, or they may extend to the cavum tympani and form the source of adhesive processes which cannot be cured.

In the affections, however, which are accompanied by great hardness of hearing, impermeability of the Eustachian tube and a great concavity of the membrana tympani, and which are generally called 'chronic catarrhs of the tube,' especially common in childhood, the disease is by no means confined to that portion of the tube, but is as a rule spread over the whole mucous membrane of the middle ear. The so-called chronic catarrhs of the tube, therefore, can only rarely be separated from the chronic catarrhs of the middle ear, and this term should only be employed, if in a given case the symptoms denote localized swelling and impermeability of the tube.

Appearance of the Membrana Tympani.—The appearance of the membrana tympani in the sero-mucous catarrhs of the middle ear

presents many varieties, which depend partly on the duration of the affection, partly on the transparency of the membrane, on the quantity, character, and colour of the exudation, and on the amount of blood-supply in the mucous membrane of the tympanic cavity.

When the membrana tympani is transparent, the accumulation of serous or mucous exudation in the tympanic cavity, as I first observed and described,* can be distinguished by a peculiar appearance of the membrane. For the fluid can be seen through the membrane in the dependent portions of the tympanic cavity, its level being sharply defined from the air-filled portion of the tympanum by a line on the membrane.

The line of demarcation, which is sometimes dark-gray or black,

FIG. 107.—ACCUMULATION OF FLUID EFFUSION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY, MARKED BY A BRIGHT LINE.

In a young man during the course of a severe cold in the head. Cured by Politzerization.

FIG. 108.—ACCUMULATION OF EFFUSION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY.

The line of the fluid level is curved and wavy. In a woman 40 years of age and syphilitic. Removal of exudation by paracentesis.

FIG. 109.—CHANGE OF POSITION OF THE LINE OF THE FLUID LEVEL OF THE EXUDATION BY INCLINING THE HEAD BACKWARDS.

In the same woman as Fig. 108.

like a hair stretched across the membrane, sometimes shining white (Fig. 107), extends either concave, convex, or wavy (Fig. 108), or the fluid may be bounded by two lines, which, commencing at the inferior extremity of the handle of the malleus, diverge downwards with a slight curvature (Fig. 110). Frequently the line of fluid level is visible only in front of the handle (Fig. 111), or only behind it, or it may be that it is seen only under a certain light as a number of irregular lines, which change their position or disappear altogether after a short time. The colour of the membrana tympani below the level of the fluid is dark and yellowish, above this line much lighter and gray. In general the yellowish colour of the exudate shining through the membrane is more pro-

* *Diagnose und Therapie der Ansammlung seröser Flussigkeit in der Trommelhöhle. W. med. Wochenschr.*, 1867; *Ueber bewegliche exsudate in der Trommelhöhle. W. med. Presse*, 1869.

nounced when it is serous or syrupy than when it is a viscid mucus.

If such lines can be observed on the membrana tympani, the diagnosis of accumulation of secretion is materially supported by the change in the position of the line, if the head is inclined either forwards or backwards. Especially when the secretion is liquid, the change in the position of the line will be very rapid, as the fluid, when the position of the head is changed, flows towards the deepest portions of the tympanic cavity (Fig. 109). If the exudation is tough and mucous the line as a rule changes its position either very slowly or not at all.

If the level of the exudation reaches the superior portion of the tympanic cavity, the line of demarcation will be wanting, because

FIG. 110.—ACCUMULATION OF A SLIGHT QUANTITY OF EXUDATION IN THE INFERIOR PORTION OF THE TYMPANIC CAVITY.

The level of the exudation is bounded by two lines meeting at the handle of the malleus. In a man with an acute catarrh of the naso-pharynx. Cure in three days after the application of my method.

FIG. 111.—ACCUMULATION OF A CONSIDERABLE QUANTITY OF EXUDATION.

The line of the fluid level is only visible in front of the handle of the malleus. In a man with a chronic catarrh of the naso-pharynx. Removal of the exudation by paracentesis of the membrana tympani.

in that case the fluid covers the whole inner surface of the membrana tympani, and the exudation can only be distinguished by the peculiar deep yellowish, greenish-yellow or reddish-yellow colour of the membrane. This reflection, which is caused by the yellowish colour of the exudation, is most strongly pronounced behind the umbo, in the region of the promontory, and it is so decidedly different from the appearance of the normal membrane that the diagnosis of accumulation of serous or mucous exudate in the tympanic cavity may be made from it alone.

Often no line of demarcation appears until air has been forced into the cavum tympani. In all these instances the lustre of the membrane is greatly increased, and the handle of the malleus is much more sharply defined than in the normal state.

The changes which are observed in the above appearances of the membrana tympani immediately after inflation are very interesting. If the exudation is serous, and the membrane remains transparent after the air has entered the tympanic cavity, the froth produced by the current of air can be plainly seen as a number of dark or lustrous well-defined rings, which change their locality when observed for some time, and are in lively motion when the secretion is fluid (Fig. 112). Sometimes at the anterior inferior margin of the field of view one or more air-bubbles will be seen to enter, which, sometimes slowly, sometimes rapidly, pass upwards out of sight.

The air-bubbles and the secretion are, however, only visible if the membrana tympani retains its transparency after inflation. Frequently, however, when the catarrh has lasted a long time the diagnosis can no longer be made

FIG. 112.—FROTHY SECRETION IN THE TYMPANIC CAVITY AFTER INFLATION IN A CASE OF ACCUMULATION OF SEROUS FLUID.

In a patient with an acute catarrh of the naso-pharynx.

FIG. 113.—APPEARANCE OF THE MEMBRANA TYMPANI IN A CATARRH OF THE EUSTACHIAN TUBE AND OF THE TYMPANIC CAVITY.

Great inward curvature of the membrane. In a boy with great deafness, which was cured by inflation after my method, continued for several weeks.

from ocular inspection through the opaque membrane, even when large quantities of secretion are present.

With regard to the curvature of the membrana tympani and the position of the handle of the malleus, it will frequently be found, especially in recent cases, that no noticeable deviation from the normal state exists; but after the catarrh has persisted for a long time, when the Eustachian tube is impermeable, the membrane is forced inwards by the excess of the external air-pressure, the handle of the malleus (Fig. 113) is strongly inclined inwards and backwards and appears shortened (v. Tröltsch), while the short process and posterior fold of the membrane project markedly outwards (Figs. 113 and 114). The short process of the hammer appears as a prominent pointed projection, and the posterior fold as a whitish or tendinous gray, sharp ridge which is sometimes straight and sometimes curved backwards and downwards, forming a sharp angle with the handle of the malleus. When the membrana tympani is excessively retracted, the handle of the malleus may be completely masked by the posterior half of the membrane and be quite invisible.

The inward curvature of the membrane in this instance is rarely uniform.

As the periphery of the membrana tympani has a greater power of resistance than the central portion, the latter is forced inwards more strongly by the external air-pressure, which produces, especially in the anterior inferior quadrant, a curve which I first described as the peripheral curve of the membrana tympani, and which can be distinguished by a linear, lustrous stria visible in that situation (Fig. 113). Besides this lustrous line, a small irregular reflection of light will also be found close in front of the inferior extremity of the handle of the malleus. The colour of the membrane is a dark, full-bodied gray (yellowish-gray in the case of exudation), mixed with a violet or reddish tinge, dependent on the intensity of the redness of the inner wall of the tympanic cavity shining through.

After a long duration of the catarrh, partial thinning of the membrane in one or more places frequently takes place, rarely in the anterior half, oftener in the posterior half. These atrophies may be present after a catarrh without

FIG. 114.—APPEARANCE OF THE MEMBRANA TYMPANI OF A MAN 30 YEARS OF AGE.

Patient suffered for two months from a catarrh of the middle ear, with great swelling of the mucous membrane of the Eustachian tube, in consequence of a cold in the head. The membrane was concave, and its colour grayish-violet. Cure of the great deafness by inflation after my method for 3 weeks.

FIG. 115.—CONDITION OF THE MEMBRANA TYMPANI IN THE SAME PATIENT IMMEDIATELY AFTER INFLATION.

producing disturbance of hearing, but occasionally produce deafness of more or less degree. They look like more or less sharply defined depressions, with one or more irregular reflections of light at their lowest part, and are very similar to the cicatrices of the membrana tympani. If the atrophied posterior portion is thinned and forced inwards to such an extent that it comes into contact with portions of the inner wall of the tympanic cavity, the long process of the incus and the posterior crus of the stapes will be seen behind the handle of the malleus as a bony yellow, angular, curved protuberance (Fig. 116). And if the membrane is also in contact with the promontory, the latter will be distinguished as a projection with a yellowish lustre behind the umbo, behind which the niche of the fenestra rotunda will be seen as a depression.

The membrana tympani, forced inwards in consequence of the impermeability of the Eustachian tube, presents only slight movement when examined by means of a pneumatic speculum. As soon, however, as the tube is made permeable by the application of my method or by catheterization, a mobility of

the membrane much greater than in the normal state will be observed during the examination with Siegle's speculum. Occasionally the presence of secretion in the middle ear may be ascertained by its being set in motion with this instrument.

If the membrane is curved inwards a remarkable change takes place in its appearance immediately after inflation. The handle of the malleus (Fig. 114) returns nearly to its normal position (Fig. 115), its vessels generally become greatly injected,* the short process of the malleus is much less prominent, and the marked posterior fold of the membrane becomes almost completely obliterated. In consequence of the great bulging out of the expanded membrane, the handle of the malleus lies almost invisible in a depressed groove of the pale membrane, which has become non-transparent (Fig. 115). Partial

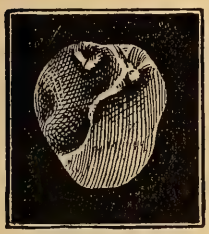

FIG. 116.—APPEARANCE OF THE MEMBRANA TYMPANI IN A YOUNG MAN, 17 YEARS OF AGE, WHO SUFFERED FOR 8 YEARS FROM CHRONIC CATARRH OF THE MIDDLE EAR.

Naso-pharyngeal catarrh, with great swelling of the mucous membrane of the Eustachian tube. Hearing-distance almost normal after one inflation by my method.

FIG. 117.—CONDITION OF THE MEMBRANE IN THE SAME PATIENT IMMEDIATELY AFTER INFLATION.

FIG. 118.—HEMISPHERICAL BULGING OF THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANA TYMPANI BY YELLOWISH EXUDATION.

In a man who contracted a catarrhal discharge in the middle ear during a cold in the head, with slight inflammatory symptoms. Cure in two weeks with air-douche.

thinnings of the membrana tympani curve outwards in a bubble-like form (v. Tröltsch), and not unfrequently the exudation, forced into them from the tympanic cavity, can be observed of a yellowish colour shining through. If the thinned portion of the membrane situated behind the handle of the malleus is curved inwards until it has come into contact with the articulation of the stapes and incus and with the promontory (Fig. 116), immediately after inflation, the portions of the inner wall of the tympanic cavity which have been visible will disappear, and instead of the previous depression, a grayish-yellow roundish or oval bulla (Fig. 117) will be observed in the posterior portion arching over the handle of the malleus either partially or

* It is produced by the rapid change of the position of the membrane and of the handle, by which the direction and relation of the vessels to those in the external meatus are suddenly changed, and a temporary stagnation in the veins of the handle takes place.

completely. The duration of such curvature outwards is, however, only very short, as, in consequence of the speedy rarefaction of air in the tympanum, the yielding portions of the membrane are forced inwards. In certain cases with sero-mucous exudate in the middle ear partial bulging of membrane like a ball takes place in the posterior superior quadrant (Fig. 118). They occur generally with slight reactive symptoms, and form the transition from a catarrh to an acute middle-ear inflammation. The connection of the tumour with the cavum tympani will be shown after the air-douche by the contrast of the gray and yellow colours which the air and secretion form in the projection.

Symptoms.—As a rule the middle-ear catarrh runs its course without pain, but in a few rare cases slight twinges of pain are felt at the beginning of the disease and in inflammatory œdema (Zaufal). More frequently, however, especially in recent catarrhs, there is produced a sensation of fulness, numbness, and pressure in the ear, similar to that felt when a little water remains in the ear after a bath. This sensation, which is frequently very unpleasant, is, according to my observation, in inverse proportion to the degree of swelling and impermeability of the Eustachian tube, as that the more trifling the swelling and deafness, the greater is the sensation of fulness, which is generally completely wanting when the tube is quite impermeable. The effort to relieve these sensations by means of frequently shaking the finger placed in the external meatus is very detrimental.

An important, though not a constant symptom, to which I was the first to draw attention, and which is most frequently observed in recent catarrhs, is the sensation as if a body were moving to and fro in the ear when the position of the head is changed, a feeling which frequently corresponds with the motion of the exudation, visible through the membrana tympani. If the membrane is opaque, the presence of free exudation in the middle ear may with probability be inferred from this symptom.

Subjective sensations of hearing in the secretive forms of catarrh are not constant, but usually intermittent. They frequently occur suddenly in cases where the disease becomes aggravated, accompanied by a sudden decrease in the hearing, and disappear just as rapidly, when an improvement in the hearing takes place either spontaneously or in consequence of treatment. That in this form of catarrh the noises are caused by the temporary increase of pressure in the labyrinth will be seen from the fact that generally immediately after inflation of the tympanic cavity, the tinnitus either ceases altogether or is considerably diminished. In cases where the tinnitus uninterruptedly continues for some time, and in spite of treatment for an impermeable tube, the prognosis will

be unfavourable, because the noises must be considered as indicating the development of permanent changes at the fenestræ of the labyrinth or some labyrinthine complication. In cases of exudation in the middle ear consecutive to pharyngeal syphilis, I have frequently observed constant subjective noises. A frequent symptom also in the secretive forms of catarrh is a crackling and snapping in the ear, which is especially noticeable upon swallowing and masticating.

The resonance of the patient's own voice is often one of the most troublesome symptoms (Autophonia). It is more noticeable in one-sided affections and in slight catarrhs than when both ears are diseased. The echo of the patient's own voice often induces him to avoid protracted conversations, and the attempts to remove this troublesome sensation by clearing the throat and blowing the nose, are successful only for a short time. Frequently this symptom disappears during treatment; it rarely remains after a cure of the catarrh has been effected.

The sensations of heaviness and numbness of the head are subjective phenomena of chronic catarrhs, to which special attention must be given. Adults often complain of a feeling of pressure and confusion in the head, through which they are rendered unfit for mental work. In children these symptoms become apparent by ill-humour and waywardness. All these phenomena generally disappear with surprising rapidity after repeated Politzerization or inflation by the catheter. Epileptiform attacks following simple middle-ear catarrh have been frequently observed (Noquet) and the relation of the two conditions proved by the cessation of the epilepsy upon treating the catarrh.

Functional Disturbances. — The functional disturbances in the catarrhs of the middle ear, accompanied by swelling and secretion, are in most cases disproportionate to the known amount of effusion; the degree of the functional disturbance depending rather on the abnormal tension of the membrana tympani and of the ossicula, caused by the impermeability of the Eustachian tube.

Considerable fluctuations in the hearing-distance, not only on different days, but also at very short intervals, have an important diagnostic significance in this form of catarrh. This depends partly on the variable tension of the sound-conducting apparatus, partly also on the change in position of the secretion.

Fluctuations in the hearing-distance are produced by various external and internal influences. In autumn and in winter, on rainy and foggy days, the hardness of hearing with catarrhs of the middle ear is, as a rule, more marked than in summer and in

dry weather. Abrupt change of temperature not unfrequently causes a sudden aggravation, as does also the excessive use of alcoholic beverages. The power of hearing is, however, subjected to the most frequent fluctuations by becoming complicated with an acute naso-pharyngeal catarrh or by exacerbation of a catarrh already existing in the naso-pharynx.

Fluctuations in the hearing-distance frequently arise quite suddenly, and generally with the sensation of a report in the ear. This symptom is specially observed in patients who, in consequence of a continuous impermeability of the Eustachian tube, were very hard of hearing for a considerable time, often for several months, and in whom the air suddenly enters the tympanic cavity, either in consequence of a spontaneous opening of the tube during an act of swallowing—the swelling of the mucous membrane having subsided to a certain degree—or on account of the removal of a mucous plug. Just as rapidly as the improvement in the hearing, there frequently takes place an aggravation with the sensation of a sudden closure of the ear, or as if a wall were placed before it.

Perception through the cranial bones for the watch and the acoumeter is almost always preserved and not unfrequently is even heard more intensely. It is only in cases of middle-ear catarrh complicated with labyrinth syphilis that perception through the cranial bones is lacking. I wish to attach special importance to this symptom, as on account of it I have repeatedly suspected syphilis, a suspicion which was confirmed by minute examination of the case. In Weber's test the tone of the tuning-fork will generally be localized in the affected ear, and only exceptionally in the better one. When complicated by labyrinth syphilis the tone will be localized generally in the normal or better ear. In slight unilateral catarrhs with otherwise negative results, the lateralization in the affected ear is an important symptom for the diagnosis of middle-ear affection. Rinne's test in slight affections of hearing is positive; with more pronounced deafness it is often negative with lengthened perception through the cranial bones.

The results of auscultation in catarrhs of the middle ear accompanied by swelling and secretion, and their diagnostic importance in the catarrhal affections here under discussion, have already been referred to in detail in the general division (p. 104).

Course and Issues.—The catarrhs of the middle ear generally run a protracted course. The course and issue are most favourable in recent simple catarrhs, or in those which have originated in the course of an acute cold in the head, as they subside spontaneously or after treatment within a few days or may extend over several weeks. Recent catarrhs after acute exanthemata, in influenza, typhus, and in scrofulous anæmic individuals, and with chronic naso-pharyngeal affections, have a protracted course.

The result of recent catarrhs is either healing or transition into the chronic state, more rarely in acute middle-ear inflammation and perforation of the membrana tympani with a serous or sero-mucous discharge for a short time. A fatal result after sero-mucous catarrh from meningitis has only been observed in single cases by Zaufal and Schwartze.

Chronic catarrhs, however, take a quite uncertain course. The great tendency to relapses of catarrhs of the middle ear, favours the transition of acute catarrh into the chronic state. After a catarrhal affection has ceased, the mucous membrane of the middle ear remains for a long time so sensitive to hurtful influences, that a slight cold, a cold bath, or a somewhat severe cold in the head suffices to produce a return of the exudation in the middle ear. It is a peculiarity of such relapses, that the renewed process exceeds the preceding affection in duration, until at last, after frequent relapses, the catarrh becomes permanent, and changes are developed which exclude the possibility of a complete restitution of function. Relapses are specially frequent in children, who are subject to either temporarily recurring or permanent catarrhs of the naso-pharynx with adenoid vegetations and hypertrophy of the tonsils. In such cases the catarrh of the middle ear recurs simultaneously with the naso-pharyngeal catarrh, mostly during the autumn and spring, and generally subside partially or altogether when the warm season comes on, to return again next autumn. In this manner catarrhs in children may regularly recur for a number of years, frequently until they are fourteen to sixteen years old, when the relapses will either completely cease or occur more rarely.

Also in adults, chronic naso-pharyngeal catarrhs, and the changes in the naso-pharynx produced by them, have a no less important bearing on the course and issue of the affections of the ear under discussion. Not only are they frequently the chief cause of the disease of the middle ear, but its catarrhal condition is maintained by the continuance of the naso-pharyngeal affection.

It has already been pointed out that the condition of the Eustachian tube has a great influence on the course of catarrh of the middle ear. It has to be added here, that even after the exudation has been completely removed from the middle ear and the hearing-function has returned to the normal state, a lasting cure cannot be expected, as long as the permeability of the Eustachian tube has not been established. Therefore, when treating catarrhs of the middle ear it must be our first endeavour to make the tube permeable, this being one of the most important conditions for normal hearing.

It is of importance, as regards both prognosis and treatment, to learn the amount and the site of the swelling in the tube. While an impermeability of the canal produced by a swelling on the ostium tubæ, which frequently occurs in cases of adenoid vegetations in the naso-pharynx, offers little resistance to treatment after the removal of the naso-pharyngeal affection, extensive swellngs in the tube produced by tumefaction and induration of the mucous membrane of the naso-pharynx require a protracted course of treatment, or are incurable. According to Hartmann it may be inferred that a swelling is confined to the ostium tubæ, if the air, propelled after my method, enters into the middle ear under great pressure only, while when the catheter is applied the air flows in freely and with the slightest pressure. If, however, great pressure is also required during catheterization, a diffuse swelling, extending over the whole tube, may be inferred.

The influence of the exudation upon the course of the pathological process depends less upon its quantity than its quality. The quantity of the exudation is by no means always a gauge of the intensity of the process, as generally in cases of trifling swelling a very copious secretion is discharged, while when a great softening of the mucous membrane is demonstrable, only a small quantity of free secretion is effused into the tympanic cavity. According to experience, affections of the latter kind resist treatment more obstinately than catarrhs accompanied by a copious discharge.

Regarding the effect of the quality of the exudation upon the course of the disease, it may be remarked, that the liquid secretions can be reabsorbed with much greater rapidity, and can be removed much more easily from the tympanic cavity, than the tough, syrupy, adhesive mucous masses.

It is beyond doubt that injurious consequences may be developed through the production of permanent pathological changes, caused by the protracted stagnation of the secretion in the middle ear. The purulent processes, such as are observed sometimes in the course of chronic catarrhs, especially in children, are probably often produced by bacterial infection of the secretion in the middle ear. An exudation which has not been reabsorbed may also produce a permanent hyperæmic condition by protracted contact with the mucous membrane, which may lead to cell-growth and to adhesive connective-tissue growth in the middle ear.

Besides the above enumerated conditions we must point out those general diseases which affect the course and issue of catarrhs in an unfavourable manner. Catarrhs also run an unfavourable course in cases of tuberculosis, Bright's disease, anæmia, marasmus, exhausting diseases and all cachexiæ, by which the nutrition of the general system has become deteriorated. In syphilitic patients sero-mucous exudation of the middle ear takes a relatively favourable course, even if combined with disease of the labyrinth.

But even in quite healthy people, in simple catarrhs as well as in those originated by extension from the naso-pharynx, and independently of the duration of the affection, adhesive processes in the middle ear are frequently developed. While, according to experience, many catarrhs even such as have existed for many years, completely subside, and therefore (if I may make use of the expression) preserve a benignant character for a long time, we may find, on the other hand, even shortly after the commencement

of a slight catarrh, that changes arise in the middle ear which permanently impair the hearing.

Diagnosis.—The diagnosis of secretive middle-ear catarrh is proved by seeing the secretion in the middle ear shining through the membrana tympani. When there are opacities in the membrana tympani which preclude the view of the secretion, the diagnosis can only be made by considering the results of auscultation, the great variation of the hearing-distance, and the marked increase in the hearing-distance after the air-douche. In such cases a collection of secretion can only be proved by paracentesis of the membrana tympani.

Prognosis.—The prognosis will be most favourable in recent simple catarrh, when the patient is otherwise healthy, when a hereditary tendency can be excluded, and when the patient is living in favourable circumstances which permit him to avoid external sources of injury. A considerable increase of the acuteness of hearing after the Eustachian tube has been rendered permeable, or after removal of the secretion from the middle ear, leads us to expect a favourable issue. In existing naso-pharyngeal affections the prognosis will be more favourable if simple swelling of the mucous membrane has to be dealt with, and no advanced, deep-seated changes in the mucous membrane have taken place. In the simple catarrhs of the tube the prognosis is relatively good if they are not combined with obstinate affections of the naso-pharynx.

The conditions which make the prognosis unfavourable are hereditary disposition, old age, continuous subjective noises, frequent relapses, long duration of the catarrh; and if after the Eustachian tube has been made permeable and the secretion has been removed, only slight increase in the hearing-distance follows; if perception through the cranial bones is decreased and shortened; if the catarrh is combined with obstinate forms of ozæna or of naso-pharyngeal blennorrhœa; restrained action of the muscles of the tube (paralysis of the palate, cleft palate); the existence of a general disease accompanied by anæmia or cachexia; or if the patient, on account of his unfavourable condition in life or on account of his calling, remains exposed to unfavourable external influences, and if he is a drunkard, or smokes excessively.

Treatment.—The most important indications to be taken into consideration in treatment of catarrhs of the middle ear, accompanied by swelling and exudation, are the establishment of the permeability of the Eustachian tube, the removal of the exudation from the tympanic cavity, and of the swelling and secretion in the mucous membrane of the middle ear. If, however, a naso-pharyngeal affection exists, it must be treated at the same time as the local

affection, and the general health, as well as the circumstances in which the individual lives, must be taken into account. As therapeutic expedient we will first consider:

1. *The Air-douche in the Middle Ear.*—In middle-ear catarrh with secretion, the air-douche, according to the author's method, attains the best result, in adults as well as in children. In the catarrhs of the cavum tympani and Eustachian tube so common in children, it has proved indispensable. The most marked and permanent improvement in hearing is produced by the method combined with swallowing. In children who will not perform the act of swallowing, the air may be forced in without it or while they speak a word (König, Barique; *vide* p. 119). The air-douche should be repeated 2 to 3 times at each treatment.

If the resistance in the middle ear is so considerable that propelling air by my method does not succeed at all, or only imperfectly, inflation by the catheter must be resorted to, with the aid of the ordinary air-bag, or, if the resistance is too great, by means of the force-pump. Experience shows that in case of great resistance it is frequently sufficient merely to apply the air-douche once, by means of the catheter, to lessen the obstruction, and that afterwards the treatment may be successfully continued by propelling air after my method.

Where, however, the air penetrates powerfully into the middle ear during the application of my method, the air-douche by means of the catheter is contra-indicated, because, as already mentioned, the frequent immediate contact of the hard instrument with the diseased mucous membrane of the tube may only increase the swelling and secretion in the middle ear.

The air-douche in the middle ear in secretive catarrhs is generally followed by a marked improvement in hearing. With slight swelling of the tube and a small amount of accumulated secretion the improvement in hearing lasts some time. In excessive swelling of the tube with copious tenacious exudates the improvement in hearing generally disappears very rapidly. The great variations which are marked at the beginning usually become less as treatment is continued. It is of importance, as the constant increase of the hearing-distance signifies a decrease of the catarrh, while the disappearance of this improvement in hearing is a symptom of undiminished continuance of it.

By means of the air-douche the accompanying head symptoms (pressure, heaviness and confusion) will be often quickly allayed. The effect is most marked in children in whom not only the uneasiness, ill-humour and aprosexia (Guye) disappear, but also the

unhealthy appearance and sickly colour disappear after a short time.

The duration of the treatment of catarrh of the middle ear by means of inflation after my method, depends on the results it produces. At first it is advisable to inflate daily, as long as the improvement in the hearing passes away for the most part again from day to day. If, however, after treatment for several days no considerable decrease in the hearing-distance is observable, the method is repeated every second, and then every third day, and if the improvement continues, at still greater intervals, once or twice a week, and finally only once a week, until no fluctuations in the hearing-distance can be noticed.

By methodical inflation in this way, a complete cure is effected in the secretive forms of catarrh of the middle ear, not only in recent, but also frequently in chronic cases, without any further local treatment. The advantages of this method of treatment, compared with that by the catheter, are sufficiently apparent from the number of cures since my method has become generally known; for no one can deny that the percentage of cured and improved patients is now considerably greater than it was when nothing but the catheter was used.

Besides the air-douche in the middle ear, in the majority of cases in which the middle-ear catarrh is combined with retraction of the membrane, rarefaction of air in the external meatus by means of Delstanche's masseur should be done after each application of the air-douche. Through the combination of both methods the effect of the treatment will be appreciably increased as well in regard to improvement of hearing as also in diminishing the subjective noises and annoying head symptoms.

2. *Mechanical removal of Secretion from the Middle Ear.*—The mechanical removal of the secretion from the middle ear is indicated when, owing to the large amount secreted and to its tenacious character, absorption is not brought about by means of the air-douche. This is effected either after a method invented by me, or by means of paracentesis of the membrana tympani.

For cases in which the exudation in the tympanic cavity is almost entirely serous, I several years ago devised a method of removing the secretion from the cavity without paracentesis of the membrane. The head of the patient, after he has taken a little water into his mouth, is placed in a position inclined well forwards and somewhat towards the opposite side, which causes the pharyngeal orifice of the Eustachian tube to point directly downwards, while the ostium tympanicum tubæ is directed exactly upwards. This position of

the head is retained by the patient for one or two minutes, so that the secretion contained in the depressions of the tympanic cavity may flow towards the orifice of the tube. Then air is propelled after my method during an act of swallowing, to allow the secretion, now deposited above the ostium tubæ, to flow into the naso-pharynx by opening the Eustachian tube. If shortly after this manipulation the membrana tympani is examined in its normal position, instead of the yellowish lustre produced by the exudation, the membrane will be found to be light gray, and in those cases in which the line of the level of the exudation was visible before inflation, it has either completely disappeared, or is considerably lower than before.

In this manner it is possible to remove the accumulated exudation from the middle ear if serous, but in those cases, however, in which the exudation forms a tough, gelatinous, consistent mass of mucus, its escape through the tube cannot be effected in the above manner.*

Paracentesis of the membrana tympani, to effect the removal of mucous masses from the tympanic cavity, was performed by Itard, Busson, Frank, Bonnafont, and Philippeaux, but without precise indications. To Schwartze belongs the merit of having introduced it into practice, so that it is now in general use, and I consider this operation, after an abundant experience, to be one of the most practically important and successful therapeutic expedients in diseases of the ear.

Paracentesis of the membrana tympani is indicated in those cases in which, after the application for several days of the methods of treatment already described, no decrease of the exudation is observed, and in which, even when no exudation is demonstrable, the improvement in hearing, the immediate result of inflation, disappears again almost entirely in one or two days. I also frequently perform the operation in those cases in which at the first examination the accumulated exudation is seen to be copious, while by this means a complete cure may be accomplished in a few days. The great advantage of this operation lies therefore in shortening the duration of treatment.†

Paracentesis of the membrana tympani is an operation so simple and easy of execution, that it can be performed by every practising physician.

The instrument used for the operation is a double-edged lancet, 6 ctm.

* The aspiration of the secretion from the cavum tympani through the tube by means of the Weber-Liel tympanic catheter has proved insufficient for its removal.

† *Diagnose und Therapie der Ansammlung seröser Flüssigkeit in der Trommelhöhle, Wien. med. Wochenschrift*, 1867, and *Ueber bewegliche Exsudate in der Trommelhöhle, Med. Presse*, 1869.

long, and with a knee-like bend near its handle, to which it is either firmly united or can be fastened by means of a small screw (Fig. 119). The latter instrument has the advantage that the lancet can be adjusted in different directions, and therefore the incision into the membrana tympani can be made with it as easily in a vertical as in a horizontal direction. Previous to the operation, the point of the lancet must be examined to ascertain that it is intact, because the pain during the operation is increased by the slightest bluntness of the instrument. Immediately before the operation the lancet should be disinfected by dipping in a 3 per cent. carbolic solution. Rohrer recommends the application of a 20 per cent. solution of cocaine to the part of the membrane where paracentesis is to be performed.

Fig. 119.—Lancet with adaptable Handle.

The most suitable site for the incision into the membrana tympani is its posterior inferior quadrant, because this place is easily accessible, and is removed further from the inner wall of the tympanic cavity than the portion of the membrane situated immediately behind the umbo, where during incision the promontory might easily be injured. If the posterior wall of the external meatus is only slightly curved, the anterior inferior quadrant (Figs. 120 and 121), which is also some distance from the inner wall of the tympanic cavity, may be chosen. If the membrane is strongly curved forward, the most prominent point of the bulging is incised.

The direction of the incision has no influence on the duration of cicatrization. For less experienced operators, Bing proposes the use of a horizontal incision, because the walls of the external meatus are not so easily injured in making such an incision as in making a vertical one.

The operation itself is performed in the following manner: The head of the patient, who is seated, is fixed either by an assistant, or by placing it against a head-rest. A speculum as wide and short as possible is inserted into the meatus, and the membrana tympani is illuminated by a light thrown into the meatus by means of a forehead mirror.

While the speculum is fixed in the meatus with the fingers of the left hand, and the place on the membrana tympani where the incision is intended to be made is closely kept in view, the instrument, held by the thumb, forefinger and middle finger of the right hand, is introduced into the meatus as far as the membrana tympani, the layers of which are rapidly cut by lowering the point of the lancet, and while removing the instrument the incision is widened to 2-3 mm. It is better to make the opening too large than too small, as tenacious masses of mucus will either not pass through a small opening or only with difficulty. The operation,

which is seldom painful, must be executed rather quickly with children and nervous patients, but always without precipitation, because from a hasty introduction of the instrument, when the eye cannot follow its point, the external meatus is frequently incised instead of the membrana tympani. Injury to the bulbus venæ-jugular, which has been observed twice (Ludewig, Hildebrandt), occurred through the abnormal dehiscence of the floor of the cavum tympani. They progressed favourably upon quickly tamponing.

Immediately after paracentesis in the somewhat gaping incision, a weak pulsation of the fluid or a distinct motion of it will be observed during speech or the act of swallowing. It is only rarely that a small drop of fluid exudes through the orifice to the external surface of the membrane; frequently, however, immediately after the operation, especially if the secretion is serous, several bubbles will be seen rising up behind the membrane during an act of swallowing, due to the entrance of air through the orifice. Sometimes a loud cracking noise will be heard in the ear during deglutition, when the margins of the perforation gape.

FIG. 120.—VERTICAL INCISION IN FRONT OF AND BELOW THE HANDLE OF THE MALLEUS.

FIG. 121.—HORIZONTAL INCISION IN THE ANTERIOR INFERIOR QUADRANT.

To remove exudation from the tympanic cavity after paracentesis it is necessary to inject air forcibly, and then the full effect of the operation is obtained. In almost all cases it will be possible to drive out the masses of secretion through the incision into the external meatus by means of my method, and that more completely than can be done by Valsalva's method or the catheter. Only in isolated cases, in which the resistance in the middle ear is very great, or in which, in consequence of paresis of the muscles of the palate and of the Eustachian tube, their action becomes insufficient during the act of swallowing, will it be necessary to inject air through the catheter into the tympanic cavity. But it may happen that the secretion can be more easily removed by blowing the nose violently than by the catheter or my method. Rohrer recommends disinfection of the naso-pharynx with a 6 per cent. solution of hydrogen peroxide before using the air-douche.

The success of the operation depends chiefly on the complete removal of the secretion from the tympanic cavity. It is, therefore, advisable to apply

my method three or four times in succession. Air and secretion pass into the external meatus, if the secretion is liquid, with a hissing and rattling noise; if the mucous masses are tenacious, however, either without any noise or with a grating sound. If the membrana tympani be then inspected, it will be found covered either with a frothy fluid, or with a yellow or brownish mucous mass. If there is only a slight quantity of tenacious exudation, the air frequently passes through the perforation without ejecting it. On the other hand, if there are great masses of exudation, and if the incision in the membrana tympani has been made too small, the mucus is jammed into the orifice of the perforation, while a portion of it hangs out like a yellowish-green mass with a pearly lustre.

If in such cases it is impossible to force the secretion from the tympanic cavity into the external meatus by repeated inflations, I employ rarefaction of air in the external meatus, for which Delstanche's masseur is especially suited; and I also make use of this method for the removal of exudation from the tympanic cavity in those cases in which the catheter cannot be introduced into the Eustachian tube in consequence of malformations in the naso-pharynx or other causes, or where the tube is closed by stricture or adhesion. I have often succeeded in removing all the secretion from the middle ear by rarefying the air in the meatus when the means by condensing the air failed. If this means is also not successful in removing tenacious secretion from the cavum tympani into the meatus, it is advisable to force it through the tube into the pharynx by forcibly compressing the air in the external meatus. If this method also fails, on account of the small opening in the membrane, it will be necessary to enlarge the incision.

The secretion that escapes into the external meatus flows off partially when the head is inclined towards the same side. Since serous secretion, as I have several times observed, flows partially back into the tympanic cavity after it has been propelled into the external meatus, I push a small pellet of wadding in front of the perforation, before propelling air for the second or third time, by which means the ejected secretion is absorbed, and cannot return into the tympanum. Tenacious mucus may be taken hold of with the bent forceps and pulled out, or removed by strongly forcing the air into the external meatus several times by means of a balloon. Injections of tepid water into the external meatus, which are recommended for the removal of mucus, should be avoided, as they may readily produce inflammatory irritation. The aspiration of the secretion through the paracentesis opening by means of a small canula inserted through it has proved worthless.

I am still more opposed to copious injections of solutions of common salt and soda through the catheter (v. Tröltsch), recommended for the liquefaction of tough mucous masses, because they frequently produce violent reactive inflammation by irritation of the mucous membrane of the middle ear and of the margins of the wound, from which protracted suppuration may follow. The same applies to forcible syringing of the tympanic cavity from the external meatus by means of a syringe, the olive-shaped nozzle of which is inserted hermetically into the external orifice of the ear.

Immediately after paracentesis, and frequently even before the removal of the secretion, relief is felt in the ear in consequence of the slackening of the

membrana tympani, and a remarkable improvement in the hearing may at once be discovered, which increases after the removal of the secretion from the tympanic cavity.

The union and closure of the margins of the incision take place generally within twenty-four hours (Schwartze), rarely only after 2-3 days. Occasionally a serous or syrupy secretion accompanies the operation, lasting several days. Consecutive inflammation of the membrana tympani and of the mucous membrane of the middle ear, which was observed by Schwartze in 25 per cent. and by Christineck in 41 per cent. of the cases, I have seen very rarely in the great number of cases operated on by me (1: 300), although the operation was frequently performed in winter in patients going about as usual. I attribute this good result partly to the careful antiseptic precautions carried out, and partly to avoiding all irritation to the membrane and cavum tympani after the operation.

To avoid all sources of danger, which might produce inflammation of the membrana tympani, the meatus must be kept closed with carbolized cotton-wool on the day of the operation, the patient must abstain from all heavy, heating work, and from exciting spirituous liquors; he must also avoid rapid changes of temperature and close and smoky rooms.

Hyperæmia, ecchymoses, and opacity of the membrane disappear in a short time; only rarely there remains a cicatricial depression on the spot where paracentesis was performed or partial atrophy of the membrane.

As regards the curative effect of paracentesis, I have observed in more than one-third of the cases operated on, especially in those of recent origin, a complete cure after once performing the operation. These are cases in which the exudative process had already ceased, the hardness of hearing being caused by the mechanical action of the exudation alone.

In cases in which the effusion from the mucous membrane of the tympanic cavity still continues, especially when there is great permanent swelling of the tube, another accumulation or exudation in the tympanic cavity will take place in a short time, so that paracentesis has to be repeated several times. In collections of fluid with atresia of the tube and facial paralysis the paracentesis, on account of its temporary effect, must be repeated at intervals for years.

The preservation of the permeability of the Eustachian tube by means of Politzerization, and the local treatment of naso-pharyngeal catarrhs, if such exist, are of importance in preventing relapses. What influence repeated inflation of air after the operation has upon the course of the disease, may be seen from the fact that in cases where two or three days after the operation a slight quantity of exudation, distinguishable by the line of its level, had again been formed, it was made to disappear after applying my method several times.

It is therefore absolutely necessary, in order to maintain the improvement that has been effected, to continue the injection of air by my method after the operation for several weeks or months, at first two or three times a week, later once every eight or fourteen days until cured.

If no constant improvement in the hearing is effected in spite of the thorough removal of the secretion, this may be traced either to a continuance

of the tumefaction of the mucous membrane of the Eustachian tube and of the tympanic cavity, to an anomaly of tension of the membrana tympani, or to adhesive processes which often occur, even during the discharge of secretion, thickening of the mucous membrane, rigidity of the articulations of the ossicula and adhesions. Swelling of the tube can be most surely proved by auscultation during catheterization. That the deafness is owing to anomalies of tension in the sound-conducting apparatus may be inferred if the tube is permeable and no secretion in the middle ear, in spite of which marked improvement in hearing occurs upon using the air-douche, which disappears again upon the membrane returning to its former position. The existence of adhesive changes may with probability be inferred if after the removal of the secretion, as well as after repeated inflations, no material improvement in the hearing results after several days. If besides there are subjective noises, which are not altered by paracentesis, it is hardly doubtful that in such a case we have to deal with a process of condensation at the fenestræ of the labyrinth.

The swelling of the mucous membrane of the tube remaining after the secretion is removed will either subside spontaneously or after the use of the air-douche. Only when the duration of the catarrh is protracted should medicated applications be made to the swollen mucous membrane. The injection of medicated solutions into the cavum tympani is not only of little use in the secretive forms of catarrh, especially when there is secretion present, but often produces very considerable harm. On the other hand, in obstinate swelling of the tube, localized medicated applications to it are often very effective. In order to introduce the medicine into the tube, without having it penetrate into the cavum tympani, eight or ten drops of the solution should be injected into the catheter with a Pravaz syringe, while the patient's head is bent to the side and a little backwards, by which means the fluid flows from the catheter into the tube. In this way concentrated solutions (Zinc. sulph. 2 in 10, Argill. acet. Burowii*) may be applied to reduce the swelling of the tube. In obstinate cases astringents are sometimes successful only when preceded by injections of ammonium chloride solution (1 in 20-30) or soda bicarbonate (3 in 10-20). Steam and ammonium chloride vapour, as recommended by v. Tröltsch and Bürkner, rarely reduce the swelling of the mucous membrane of the tube. Turpentine vapour has proved more useful, it being aspirated from the vial with the balloon and forced through the catheter into the middle ear. Bronner (*Arch. of Otology*, 1891, vol. xx.) recommends the vapour of Ol. eucalypti and menthol.

The application of medicated fluids to the mucous membrane of the tube is most effective if alternated with the air-douche by means of my method or the catheter (on one day the injection, the next the air-douche). The improvement in hearing from this combined treatment is generally very noticeable. Where fluid injections act unfavourably one must return to the use of the air-douche alone.

Where the swelling of the tube is persistent, and the air can be forced into

* Alum. crudi 70·0; Solv. in aqua dest. 280·0; Plumb. acet. cryst. solve in aqua dest. 280·0; Liqu. mixt. filtra et dilue pond. 800·0. Serv. in vitr. bene clauso.

the ear only with difficulty, the introduction of medicated bougies into the tube are recommended (Albert H. Buck). I use most frequently catgut bougies (thin violin strings), which are impregnated with a concentrated solution of nitrate of silver (1 in 10), then dried and pushed through the catheter as far as the isthmus tubæ and left there for three or five minutes. Often after the third to fourth introduction of these bougies (every 2-3 days) the passage of the tube is open, so that air may be forced through by my method. If these bougies soaked in the silver solution be left in the tube too long they may produce reactive middle-ear inflammation. In swelling of the tube which has lasted a long time, I have used with advantage massage (2-3 minutes) below the auricle on the side of the neck between the inferior maxilla and the mastoid process.

In catarrhs of the tube and cavum tympani which had resisted all treatment, I have often seen complete healing take place if the patient at the beginning of warm weather went to reside in the Alps.

In secretive middle-ear catarrhs the treatment should not be continued more than a certain time, as I have previously mentioned. As the same rules apply here as in catarrhal adhesive processes (dry catarrh) of the middle ear, I would refer to the treatment in the next section. Under the head of naso-pharyngeal affections will be considered the after treatment, hygienic circumstances of the patient, the diet, etc.

(b) The Catarrhal Adhesive Processes in the Middle Ear.

Syn.: Otitis media catarrhalis chronica; Otitis media catarrhalis sicca; Otitis media sclerotica; Proliferous inflammation of the middle ear (Roosa); Otitis media iperplastica (de Rossi).

Catarrh of the middle ear, accompanied by sero-mucous exudation, having been described in the previous division, we will in the present one discuss those adhesive processes which arise in the course of chronic catarrh, and form the basis of permanent defects in hearing.

Attention has already been specially drawn to the fact that a sharply defined separation of the exudative catarrhs of the middle ear from the adhesive processes which are developed from them, is not practicable. For while those anatomical changes, yet to be described as permanent obstacles to the conduction of sound, are generally developed only after the catarrhal exudation has passed away, it has been sufficiently proved by pathological observations that the new-formation of adhesive connective tissue very often takes place even during the exudative stage of the disease, and that in the course of many adhesive processes the catarrhal secretion does not cease, but is continuous throughout.

It has also been specially mentioned, that adhesive processes in the middle ear do not always originate in exudative catarrh, but

often, without a preceding catarrh, an insidious interstitial inflammation is established in the lining membrane of the cavity, during the course of which rigidity of the ossicular chain, but most commonly anchylosis of the stapes, results, owing to condensation and contraction of the lining membrane and of the ligamentous apparatus in the tympanic cavity. These are the diseases of unfavourable prognosis, commencing usually with trifling symptoms, showing, as a rule, an insidious course, and ending in the highest degree of defective hearing.

The adhesive processes here outlined are much more frequently accompanied by symptoms which point to a simultaneous affection of the labyrinth, than other forms of inflammation. The insidious forms especially, which often end in anchylosis of the stapes, are more frequently combined with disease of the labyrinth than the adhesive processes arising from true catarrh. However, affections of the labyrinth (atrophy, fatty and colloid degeneration) often occur in conjunction with the last-named forms, especially if of long duration.

After a short duration of the disease, or even at its commencement, a combination of symptoms is frequently present which leaves no doubt as to the presence of disease of the labyrinth. With such decided labyrinthine symptoms appearing even at the outset of the affection, we are often driven to the assumption from clinical observation, that both divisions of the ear, the tympanum and the labyrinth, have been affected at the same time and by the same disorders of nutrition; in the beginning of the disease, however, the labyrinthine disturbances sometimes prevail to such an extent that we must doubt whether in such cases the primary disease did not originate in the labyrinth, and the development of the obstacles to the conduction of sound did not occur later.

From the foregoing it can be seen, that many various forms of disease of the middle ear have been comprehended in the group of adhesive processes, showing many anatomical as well as clinical differences. The association of those interstitial inflammations of the middle ear, so singular in their course, and chiefly confined to the neighbourhood of the labyrinthine fenestræ, with the adhesive processes originating with catarrhs, according to the present state of our knowledge is based only on the fact that obstacles to the conduction of sound exist in both forms. As v. Tröltsch correctly remarks, there is no doubt that, through extension of our anatomical knowledge, this interstitial form of inflammation may attain to a separate position in the series of diseases of the ear. For in those cases

where from its commencement it progresses without catarrhal symptoms, it appears as a distinct disease, showing in the majority of cases quite a different character from that of the adhesive processes originating in true catarrh.

Pathologico-anatomical Alterations.—The pathological alterations in the adhesive processes either extend over the whole mucous membrane of the middle ear, or occur in circumscribed areas. The former may be called diffused, the latter circumscribed inflammatory processes. The diffused changes most frequently arise from the secretive forms of catarrh of the middle ear, while the circumscribed obstacles to the conduction of sound, especially those which are developed in the neighbourhood of the fenestræ of the labyrinth, are mostly products of the interstitial form of inflammation of the mucous membrane (sclerosis).

The structural changes in the mucous membrane consist generally in partial or total transformation of the new-formed round cells into fibrous connective tissue, interstitial hypertrophy of the mucous membrane with retrograde metamorphosis of the new-formed tissue, shrinking, sclerosis, atrophy, and calcification.

In cases where the exudative stage has not yet passed away, the hyperæmic mucous membrane, usually unevenly tumefied, appears yellowish or bluish-red, infiltrated with serum, gelatinous, spongy, easily movable, uneven in surface, glandular, and shaggy. In consequence of this excessive proliferation of the mucous membrane, the depressions in the tympanic cavity, especially the niches of the fenestræ ovalis and rotunda, as well as the attic of the cavum tympani, are filled with succulent connective tissue, partially of new formation, which covers the head of the malleus and body of the incus. Occasionally the mastoid antrum and mastoid cells are filled with masses of œdematous connective tissue, or that inconstant fibrous network which extends from the malleus and incus into the mastoid antrum (p. 36) is thickened and hypertrophied. The mobility of the ossicula is impaired, but seldom quite lost by anchylosis at this stage (Zaufal). The increase in thickness of the lining membrane is caused partly by proliferation of the round cells, partly by new-formed connective tissue. Therefore, by the round cells undergoing fatty degeneration, a partial repair of the mucous membrane may take place.

In other cases where the secretion has totally ceased, and where a complete transformation of the new-formed tissue into connective tissue has already taken place, we find the mucous membrane generally smooth, several times as thick as usual, pale, of a dull, tendinous-gray colour, rigid, firmly united with its base, and only slightly movable. The condensation and rigidity affect not only the lining membrane of the tympanic cavity, but often also the folds of the mucous membrane and the ligaments which extend to the ossicula, as well as the covering of the articular capsules. This thickening is generally most strongly marked where the ossicula touch the walls of the tympanic cavity. Only rarely partial calcification of the mucous membrane occurs and mostly on the promontory, as well as hyperostotic narrowing of the

cavum tympani (Moos and Steinbrügge).* In those insidious cases, which occur quite often, limited to the niche of the fenestra ovalis and producing anchylosis of the stapes, the mucous membrane in the pelvis ovalis seldom exhibits any macroscopical changes, as the process of shrinking and calcification takes place more deeply in the layers of the periosteum.

In yet another series of cases we find the tympanic cavity traversed by

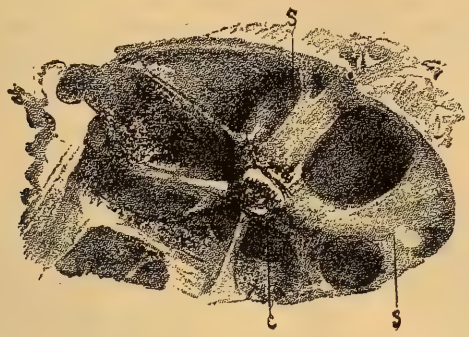

FIG. 122.—NICHE OF THE FENESTRA OVALIS, WITH THE CRURÆ OF THE STAPES IN THE NORMAL EAR OF AN ADULT. NETWORK OF BANDS EXTENDING FROM THE NECK OF THE STAPES TO THE WALLS OF THE NICHE.

c, Head of the stapes; *ss*, Cruræ of the stapes.

numerous membranous striæ and bands, which often cross each other, and by which the membrana tympani, the ossicula, and the tensor tendon, are abnormally connected with each other and with the walls of the tympanum, producing abnormally increased tension of the sound-conducting apparatus

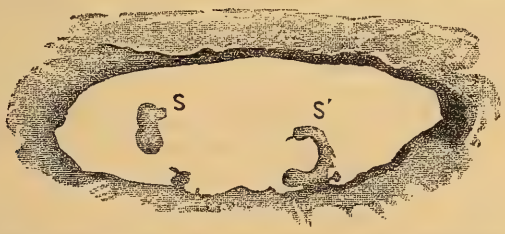

FIG. 123.—CROSS SECTION THROUGH THE NICHE OF THE FENESTRA OVALIS AND THROUGH BOTH CRURÆ OF THE STAPES IN A NORMAL EAR.

s, Section of the posterior free crura of the stapes; *s'*, Section of a bridge of mucous membrane, with the anterior crura adherent to the wall of the niche.

with deafness of different degrees. These bands cannot be considered as primary pathological formations, but as thickened bands and folds which are so often met with in the normal ear as residue of the fœtal mucous membrane cushion (Fig. 122). In some rare cases such striæ are transformed by a

* Steinbrügge, *Pathologische Anatomie des Ohres*, in Ziegler's *Patholog. Anatomie*, 1890.

deposit of calcareous salts into bone-like processes (Toynbee, v. Tröltsch). We further find circumscribed or extensive adhesions between the membrana tympani and the inner wall of the tympanic cavity, and sometimes a partial or complete obliteration of the attic of the whole cavum tympani, by transformation of its excessively proliferated mucous membrane into connective tissue, and its complete and general union with the inner surface of the membrana tympani and the covering of the ossicula.

Through these alterations in the tympanic cavity, the power of vibration of the conducting apparatus is more or less impaired. The greatest obstacles to conduction arise from the intimate attachment of the ossicula to the walls of the

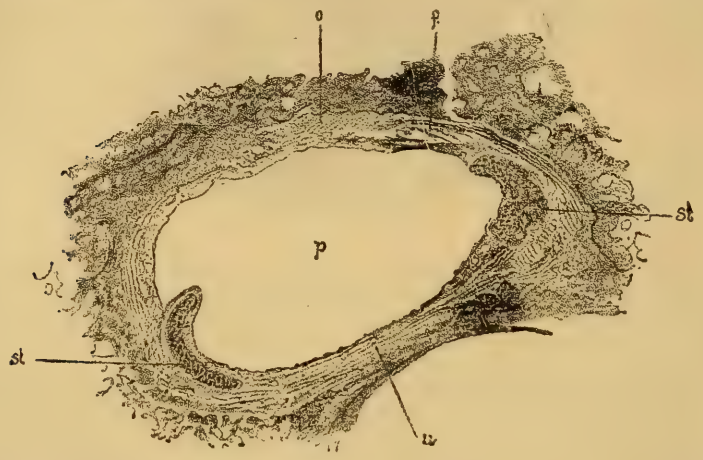

FIG. 124.—ADHESION OF THE CRURA OF THE STAPES WITH THE LOWER WALL OF THE PELVIS OVALIS, FROM THE LEFT EAR OF A WOMAN AGED 48 YEARS, WHO GRADUALLY GREW DEAF, THE LEFT EAR DATING SINCE 20 YEARS, THE RIGHT 10 YEARS. MICROSCOPICAL SECTION THROUGH THE PELVIS OVALIS AND THE CRURÆ OF THE STAPES.

p, Pelvis ovalis; *o*, Upper wall of the niche; *n*, Mucous membrane of the lower wall of the niche, which is infiltrated with fibrous sclerosed connective tissue; *st*, *st*, Sections of cruræ of the stapes covered with tough fibrous connective tissue. (After a preparation in my collection.)

tympanic cavity and from anchylosis of the ossicular joints. This anchylosis is due to the formation either of a tense fibrous tissue (anchylosis membranacea s. spuria), or of osseous substance (anchylosis ossea s. vera). The anchylosis affects either all the ossicula, or each of them may be separately united with the adjoining walls of the tympanic cavity. We find, therefore, sometimes an anchylosis between the head of the malleus, alone or together with the body of the incus to the tegmen tympani or the external wall of the tympanic cavity. Several times in congenital deafness I have found the long process of the incus adherent to the posterior wall of the cavum tympani.

Among the most important results of chronic inflammation of the mucous membrane of the middle ear, is anchylosis of the stapes with the fenestra ovalis. This lesion has been known since the time of Morgagni, who was the

first to describe and show preparations of it. To Joseph Toynbee, however, belongs the great merit of having shown, by numerous post-mortem examinations, that those disturbances of hearing, which formerly were classed under the name of 'nervous deafness,' are caused by it in the majority of cases.

The anchylosis of the stapes is generally the result of a diffused inflammation of the mucous membrane of the tympanic cavity, and is often complicated with anchylosis of the malleus and the incus, with adhesions between the membrana tympani, the ossicula, and the inner wall of the tympanic cavity, and with the formation of striæ and bridges in that cavity, sometimes also with thickening and calcification of the membrane of the fenestra rotunda.* Often, however, it follows from circumscribed interstitial inflammation of the mucous membrane, when the pathological changes are prin-

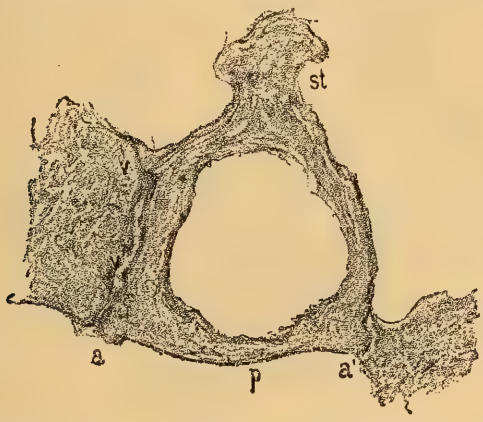

FIG. 125.—HORIZONTAL SECTION THROUGH THE NICHE OF THE FENESTRA OVALIS AND STAPES OF A MAN AGED 77, WHO WAS NEARLY DEAF. ADHESION OF THE POSTERIOR CRURA OF THE STAPES WITH THE CORRESPONDING WALL OF THE NICHE.

p, Base of the stapes; *st*, Head of stapes; *a*, *a'*, Stapedio-vestibular articulation; *v*, Adherence of the crus post. stapedius with the wall of the niche. (After a preparation in my collection.)

cipally confined to the neighbourhood of the fenestra ovalis, no signs of disease being visible in the other portions of the middle ear.

Anchylosis of the stapes arises either through a union of the margin of its footplate with the circumference of the fenestra ovalis (anchylosis of the footplate of the stapes) (Figs. 126 and 127), or through union of its crura with the inferior wall of the niche of the fenestra ovalis* (anchylosis of the crura of the stapes) (Fig. 124).

Often I have found the crura of the stapes adherent to the anterior or posterior wall of the niche (Fig. 125), and more rarely (especially in congenital deafness) adhesion of the crura and head of the stapes with the upper wall of the niche. The anchylosis of the stapes is undoubtedly

* Compare A. Politzer's paper on Histological Changes in the Fenestræ Ovali and Rotunda. International Congress, Brussels, 1888.

favoured by congenital narrowing of the niche of the fenestra ovalis, and by the presence of those thread and band-like filaments which one often finds in the niche of the fenestra ovalis in large numbers as residuum of the fœtal life, surrounding the cruræ of the stapes as a thick network (Fig. 122). Even when these filaments and bridges of mucous membrane appear to be absent, one finds by closer examination separate bridges of mucous membrane which connect the cruræ of the stapes with the wall of the niche (Fig. 123). The more closely the contact of the cruræ and wall of the niche normally, the easier will inflammation produce adhesion of the surfaces (Politzer, Gradenigo).* Within a short time I have dissected three cases of deafness in which the stapes was fastened to the pelvis ovalis by the growth of a bony tuberosity.

Anchylosis of the footplate of the stapes with the circumference of the

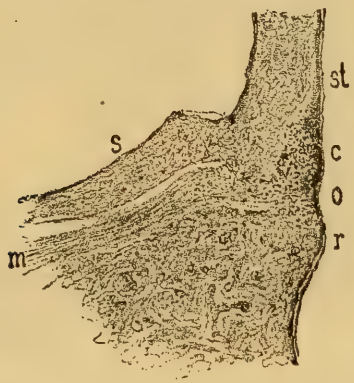

FIG. 126.—HORIZONTAL SECTION THROUGH THE STAPEDIO-VESTIBULAR ARTICULATION IN A MAN WITH PROGRESSIVE DEAFNESS OF A HIGH DEGREE.

st, Plate of the stapes; *s*, Crura of the stapes; *c*, Cartilaginous ring of the plate of the stapes, infiltrated with calcareous molecules; *r*, Edge of the fenestra ovalis; *o*, Calcareous infiltrated ring of the stapes; *m*, Sclerosed connective tissue between the crura of the stapes and niche of the fenestra ovalis. (After a preparation in my collection.)

fenestra ovalis is caused either by calcification and ossification of the ligamentous ring of the stapes (Fig. 126), by a growth of cartilage from the circumference of the fenestra ovalis (Wendt), or by deposit of new-formed osseous substance upon the inner surface of the footplate, and in the neighbourhood of the fenestra ovalis. Corresponding with the tendinous ring we find in the latter case, on the labyrinthine side of the fenestra ovalis, a concave osseous deposit, which slopes down towards the middle of the footplate of the stapes. There may also be, as I first observed, a complete bony union of the footplate of the stapes with the wall of the fenestra ovalis (Fig. 127). The edges of such synostoses are indistinguishable in some cases (Katz), and in others are marked by a dark line.

Not less important are the pathological changes in the fenestra rotunda. One also finds here, often in normal cases, separate threads or a fibrous network

* Congrès Otologique. Bruxelles, 1888.

stretched across the niche which leads to the fenestra rotunda. These are in connection with the membrane of the fenestra rotunda, and form the foundation for hypertrophic thickening of the mucous membrane covering it. I have found most frequently in my examinations (*l. c.*) the niche of the fenestra rotunda filled with a mass of connective tissue, the membrane thickened (Fig. 128), covered with a villous growth, and the niche greatly narrowed or completely closed. Calcification of the fenestra rotunda was observed in a few cases by Toynbee and v. Tröltsch.

Besides the changes in the stapedio-vestibular connection in adhesive processes in the middle ear, one occasionally finds changes in the other articulations of the ossicula. Of these may be mentioned: thickening of the mucous membrane covering the malleo-incudal articulation or anchylosis of

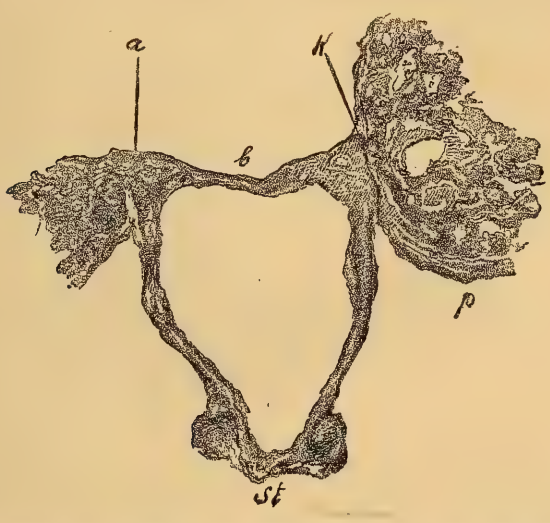

FIG. 127.—ANCHYLOSIS OF THE PLATE OF THE STAPES WITH THE FENESTRA OVALIS. MICROSCOPICAL SECTION THROUGH THE STAPEDIO-VESTIBULAR CONNECTION.

st, Head of the stapes; *b*, Base of the stapes; *p*, Promontory; *a*, Spurious adhesion of the border of the stapes with the fenestra ovalis; *k*, Adhesion of the anterior border, the edge being still noticeable by the dark line. (Right ear.) (After a preparation in my collection.)

it (Toynbee, Zaufal, v. Tröltsch), by which, as I proved histologically, the cartilaginous articular surfaces incrusted with calcareous material are adherent to the meniscus and to each other. Anchylosis of the articulation between the stapes and incus was found by Toynbee only twice among 1,149 dissections.

The pathological alterations in the Eustachian tube are generally dependent on the extent of the inflammatory process in the middle ear. In the diffused forms, especially in those connected with chronic naso-pharyngeal affections, sometimes a moderate, sometimes a great narrowing of the tube takes place. Kirschner found in one case a formation of diverticuli on the floor of the canal of the tube. By my examination I have several times found the

mucous membrane covered with several layers of cylindrical or laminated epithelium which were infiltrated with fat globules, the glandular layer was hypertrophied in some cases (often through retention of secretion, Moos), in others atrophied, once completely lacking. The mucous membrane is covered with excrescences, papillary, or smooth and atrophic, the cartilage infiltrated with fat globules and pigment, and sometimes atrophic. In circumscribed interstitial inflammations, however, the Eustachian mucous membrane is, as a rule, normal, and the tube is therefore completely permeable. This holds good, however, only in the majority of cases; for, just as in cases where there have been adhesive processes, after catarrh has passed away, there may remain a freely permeable and even very wide Eustachian canal (v. Tröltsch), so we often find a pronounced stricture of the Eustachian tube in the circumscribed forms of inflammation in the tympanic cavity.

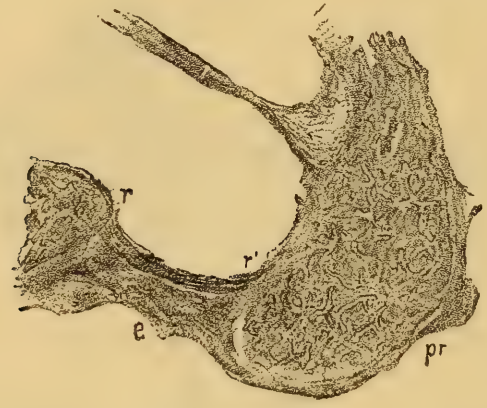

FIG. 128.—ANTERIOR SECTION THROUGH THE NICHE OF THE FENESTRA ROTUNDA IN A WOMAN AGED 80 YEARS. THICKENING AND HYPERTROPHY OF THE MUCOUS MEMBRANE COVERING THE FENESTRA ROTUNDA FOLLOWING MIDDLE EAR CATARRH.

pr, Promontory; *r*, *r'*, Membrana fenestr. rotundæ; *e*, Hypertrophic mucous mem. covering the membr. fenestr. rotund. (After a preparation in my collection.)

The alterations in the muscles of the Eustachian tube are of consequence in so far as by their decreased power of action the necessary ventilation of the middle ear is interrupted. Besides the paralytic conditions to which we will revert later on, we must especially mention fatty degeneration of the muscular apparatus of the pharyngeal portion of the tube met with in cases of long-standing inflammation of the naso-pharynx, also atrophy and cicatricial contraction of the muscles as consequences of ulceration (syphilis, scrofula) of the naso-pharyngeal mucous membrane, restricted action of the muscles in defects of the palate, cleft palate, and adhesion of the vela palati to the walls of the pharynx.

The changes in the intra-tympanic muscles occurring in chronic adhesive affections are to be considered as secondary processes. They consist of fatty degeneration, atrophy, and cicatricial or colloid degeneration (Moos), deve-

loped partly by inflammation of the neighbouring mucous membrane of the middle ear, partly by the arrested action of the muscles, in consequence of anchylosis of the ossicula. Very often in long-continued anchylosis of the stapes I could find no change in the intrinsic muscles of the ear.

Etiology and Occurrence. — The most frequent causes of the adhesive processes are the following:

(1) Frequent recurrence of secretive catarrh; (2) chronic naso-pharyngeal catarrh and ozæna, by which recovery from the existing middle-ear affection is retarded; (3) paresis and paralysis of the muscles of the palate and tube, which, with facial paralysis, sometimes occur as the sequelæ of diphtheria; also fatty degeneration and atrophy of the same, by which the necessary ventilation of the middle ear is prevented; (4) general diseases, especially scrofula, tuberculosis, syphilis, Bright's disease, chronic rheumatism, anæmia and marasmus; (5) pregnancy and the puerperal state; (6) hereditary predisposition, (according to Moos in 37 per cent., and according to Bezold in 43 per cent. of the cases); (7) external sources of injury, especially such as, in consequence of the occupation of the patient, continually operate upon the organism, living in a damp house, excessive applications of hydropathy (v. Tröltsch), and protracted sea-bathing during the existence of middle-ear catarrh; (8) the immoderate use of alcoholic liquors and excessive smoking (Triquet, Ladreit de Lacharrière), by which the development of permanent new-formation of tissue in the mucous membrane of the middle ear is favoured in chronic catarrh.

The adhesive processes in the middle ear occur most frequently in middle-aged and old people, less frequently in children and young persons, who are most subject to the exudative forms of catarrh. The development of adhesive processes in the middle ear, which have arisen during childhood in consequence of catarrhs, can easily be traced to disturbance of nutrition, especially scrofula, anæmia, or to hereditary tendency. In a not inconsiderable number of cases, the adhesive processes in the middle-aged are caused by catarrhs which date from childhood.

Adhesive inflammation of the middle ear usually affects both ears, being seldom confined to one only. The disease generally presents the same character in both ears; often, however, the phenomena of secretive catarrh appear in one ear while in the other there exists an interstitial adhesive inflammation of the mucous membrane (dry middle-ear catarrh). But the combination of the last-named form of disease in the one ear, with purulent perforating inflammation in the other, is not uncommon.

Condition of the Membrana Tympani.—The colour and trans-

parency of the membrane are most frequently affected in adhesive processes of the middle ear, the membrane being partially or wholly rendered dull and non-transparent.

In the former case, the parts affected appear as definite or ill-defined opacities, of a tendinous-gray colour, striated or spotted, and between these the normal or less obscured portions of the membrana tympani appear as dark spots, apparently depressed. These opacities vary greatly in size and shape. Among the more frequent shapes is the semilunar, situated behind the hammer, with the convexity turned towards the periphery, and of the colour of milk-white glass or tendinous-gray, a form which, unlike the chalky

FIG. 129.—SEMILUNAR OPACITY BEHIND THE HANDLE OF THE MALLEUS IN A WOMAN 38 YEARS OLD.

Duration of the ear disease 6 years; greatly aggravated during the last 3. Acoumeter = 1 cm. Speech = 10 cm. Perception through the bones of the skull unaltered. Tuning-fork on vertex heard best in the affected right ear.

FIG. 130. — SEMILUNAR CHALKY DEPOSIT IN FRONT OF THE HANDLE OF THE MALLEUS IN A MAN 38 YEARS OLD.

FIG. 131. — HORSESHOE CHALKY DEPOSIT IN THE MEMBRANA TYMPANI OF A WOMAN 30 YEARS OLD.

Duration of the ear disease 10 years. Tinnitus seldom. Acoumeter = 30 cm. Speech = 3 m.

deposits, is not sharply defined, but merges into the transparent parts of the membrane (Fig. 129), its margins gradually becoming less distinct. Peripheral, whitish-gray and circular opacities are frequently found, comparable to the arcus senilis of the cornea, and due to the thickening of the mucous membrane of the periphery of the membrana tympani and opacity of the annulus tendinosus.

A more rare condition found in this middle-ear process is the calcareous deposits on the membrana tympani as chalky white, sharply defined spots, situated between the handle of the malleus and the periphery. They are found most frequently in front of the handle of the malleus, more rarely behind it, in the shape of a crescent, directed with its convexity towards the periphery (Fig. 130). Sometimes a chalky spot is visible both in front of and behind the

handle, or the inferior extremity of the handle is surrounded by a horseshoe-shaped deposit (Fig. 131).

Not less frequently the membrana tympani is rendered non-transparent in its whole extent. In this case it appears sometimes irregularly spotted gray, sometimes of a homogeneous bluish-white colour, like a glass surface that has been breathed upon, sometimes as a sodden whitish-gray membrane, almost perfectly opaque, the aspect of which might be compared to a lustrous milk-white glass plate, upon which the posterior fold of the membrana tympani is plainly marked. In great thickening of the membrana tympani, and with its extensive union with the inner wall of the tympanum, the membrane presents the appearance of a yellowish disc of parchment. In cases in which the growth of connective tissue producing adherences in the cavum tympani is hyperæmic or pigmented the membrana tympani has a reddish-gray or bluish-gray appearance.

The appearance of the handle of the malleus is often also perceptibly altered. Its margins often seem ill-defined, the handle itself apparently widened, and the umbilical opacity increased.

The cone of light either shows the normal, triangular shape, or is irregular, indistinct, much narrowed or shortened by retraction of the membrana tympani (seldom lengthened).

The curvature of the membrana tympani in the chronic adhesive processes suffers striking alterations.

To a greater or less extent the membrane appears drawn inwards, thickened, or atrophied and wrinkled; the handle of the malleus appears foreshortened, displaced inwards, backwards, and upwards, and partly covered; the short process and the fold of the membrane extending backwards (Fig. 132) or downward (Fig. 133) from it seem very prominent.* Two short folds frequently extend simultaneously from the proc. brevis towards the Rivinian segment, and enclose Shrapnell's membrane, which is either depressed or united with the neck of the malleus. The membrana tympani is either thickened or, as occurs more often than is generally supposed, atrophic; in the latter case with a formation of radiating folds and multiple linear light reflexes.

In addition, circumscribed retractions, similar to scars on the membrana tympani, are not unfrequently observed. These are caused either by partial atrophy (Fig. 134), by ligamentous adhesions, or by immediate union of the membrana tympani with

* As Bing was the first to observe, in rare cases a second fold is to be seen underneath the posterior fold of the membrana tympani, extending from the middle of the handle of the malleus towards the posterior margin of the membrane.

the inner wall of the tympanic cavity (Fig. 135). Their number and extent are very variable. They appear as slight round or oval depressions on the membrane, occurring now and again with opaque or thickened portions of the membrane round them (Fig. 134), or they are met with as extensive depressions, mostly situated behind the handle of the malleus, which come into contact with the deeper parts of the tympanum, and not unfrequently bring into view the outline of the articulation between the incus and stapes. In adherence of the membrana Shrapnelli with the neck of the malleus one sees above the short process a marked depression in the region

FIG. 132. — WELL-MARKED INWARD CURVATURE OF THE LEFT MEMBRANA TYMPANI OF A YOUNG MAN, HARD OF HEARING FOR 6 YEARS.

Acoumeter only on contact. Speech, 5 cm.; after Politzerizing, 1 m.

FIG. 133.—RETRACTION OF THE MEMBRANA TYMPANI, PERSPECTIVE SHORTENING OF THE HANDLE OF THE HAMMER, SEMICIRCULAR PROMINENCE OF POSTERIOR FOLD.

From a woman who had chronic middle-ear catarrh for 7 years. Acoumeter = 4 cm., speech = 1 m. Rinne negative.

FIG. 134. — CIRCUMSCRIBED DEPRESSIONS IN THE ANTERIOR INFERIOR QUADRANT OF THE LEFT MEMBRANA TYMPANI OF A SCROFULOUS GIRL, 12 YEARS OF AGE, WHERE THE ALTERATIONS ON THE MEMBRANE HAD BEEN DEVELOPING THEMSELVES FOR SEVERAL YEARS UNDER OBSERVATION.

Handle of the malleus strongly inclined inwards and backwards, the posterior superior segment of the membrane united with the articulation of the incus and stapes. Acoumeter = 1 cm., speech = $\frac{1}{2}$ m.; after Politzerizing, acoumeter = 15 cm., speech = 2 m.

of which the neck of the malleus appears (Fig. 136). Often one finds atrophic spots in the posterior superior quadrant of the membrana tympani bulging outwards.

In those circumscribed inflammations of the mucous membrane of the middle ear limited to the fenestra ovalis and going on to fixation of the stapes one often finds the membrana tympani quite normal, occasionally, however, dull, opaque, and atrophic.

An important, but not constant, symptom of such processes confined to the vicinity of the fenestra ovalis, is the appearance of hyperæmia of the promontory, shining through the membrane (Schwartze), as a distinct reddish glimmer behind the umbo. If

the hyperæmia affects the whole covering of the cavum tympani then the redness showing through the membrana tympani extends over its whole surface. This condition is frequently met with in those severe forms in which the ear-affection runs its course with continued subjective noises, with rapidly-increasing deafness, and early disappearance of perception through the bones of the head.

The external meatus in the inveterate forms is often dry, without trace of ceruminal secretion, more frequently, however, covered with a dense brown secretion.

Subjective Symptoms. — Subjective noises are among the most frequent and annoying symptoms of adhesive middle-ear inflammation. While the subjective ear-sensations in cases of middle-ear catarrh, complicated by secretion, are either absent altogether or only transient, in the majority of cases of adhesive middle-ear

FIG. 135.—CIRCUMSCRIBED ADHESION OF THE MEMBRANA TYMPANI TO THE PROMONTORY UNDERNEATH THE HANDLE OF THE MALLEUS.

a, Place of adhesion on the promontory. (After a preparation of mine, now in the museum of the College of Physicians in Philadelphia.)

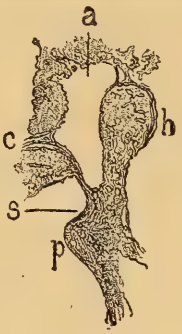

FIG. 136.—SECTION THROUGH THE MALLEUS AND THE EXTERNAL ATTIC OF THE CAVUM TYMPANI.

h, The head of the malleus; *p*, Proc. brevis; *a*, External attic; *s*, Membrana Shrapnelli adherent to the neck of the malleus; *c*, Vascular canal leading from the external attic into the meatus. (After a preparation in my collection.)

inflammation the noises are continuous. Often intermittent and weak in the beginning of the disease, the noises become continuous as it proceeds, and frequently increase in intensity in proportion as the acuteness of hearing decreases. They are not always of the same intensity, but are usually loudest in bad and windy weather, after partaking of alcoholic beverages, when the patient is affected with a severe cold in the head, after severe mental exertion, nervous excitement, or great fatigue, during bodily indisposition and pregnancy, etc. Sometimes attacks of excessive loud noises are experienced spreading from the ear through the whole head.

While, during the first part of the disease, many are very un-

pleasantly affected by the noises, but, as they affirm, gradually get used to them; in other cases, even after many years' duration, the tinnitus continues to cause the most unbearable torture, which embitters the patient's life. In consequence of such intense noises in their ears and head, many patients are continually in a stupid, often mentally depressed condition, from which they cannot be relieved by any kind of diversion. In general, the noises are felt much more distressingly by nervous, hysterical, anæmic, and ill-fed individuals, than by strong, healthy persons. Children who are affected with continuous noises seldom complain of the unpleasantness of the sensation.

The subjective ear-sensations and the disturbance of the function of hearing appear often simultaneously. In many cases, however, the noises are present long before deafness is developed, as the only symptom of adhesive middle-ear inflammation. In other cases hardness of hearing is the first symptom, to which the subjective noises are added later on. With increase of deafness the noises, as a rule, also increase in intensity, and they may continue after complete deafness occurs. Not unfrequently, however, they become weaker as the deafness increases, until with completely established deafness every subjective ear-sensation ceases.

Sensations of pain in the ear in the adhesive processes are on the whole observed but seldom, and are either of neuralgic nature or following intercurrent reactive inflammation. On the other hand, one sees often in the beginning of the disease, more often, however, in high degrees of deafness, a great sensibility to noises (hyperæsthesia acustica), especially for shrill tones, music, and loud speech.

There is much more frequently, especially in inflammation accompanied by continuous noises, a great fulness in the head, a sensation of weight and pressure on the brain, temporary or permanent dizziness, and more or less giddiness. The latter symptom, which follows sudden congestive hyperæmia or exudation in the labyrinth, occurs often in an attack associated with sickness, vomiting, unsteadiness of gait, marked increase of the ringing in the ear, and a sudden change for the worse in the hearing, which often remains (Menière's group of symptoms); or the attack is less intense, of shorter duration, and disappears without any bad consequences. Psychical depression, inability to think (v. Tröltsch), aprosexia (Guye) and inability to apply the mind, are not rare in this form of middle-ear disease.

Disturbances of Hearing.—The degree of disturbance of hearing is generally dependent upon the extent of the hindrance of sound-conduction to the fenestræ of the labyrinth and the accompanying

changes in the labyrinth itself, although this is not always the case (Burckhardt-Merian). Great variations in the hearing-distance, especially marked increase, are much rarer than in the secretive catarrh. Most patients hear better in the morning than in the evening. Transient marked deafness is often observed during mastication. Conditions of the weather and temperature have less influence upon the function of hearing than in the secretive catarrh. According to Urbantschitsch, the function of hearing in one ear may decrease within a certain time, while that of the other ear increases (alternating deafness). Changes in temperament, bodily indisposition, and general diseases, usually have a detrimental effect upon the hearing. The deafness for speech is most marked, while often very slight noises—for example, the falling of a needle—are easily heard. Similarly, persons with a high degree of deafness often hear the finest variations of music and singing completely when not at too great a distance. Only at a greater distance the perception for the weaker (piano) musical tones is lost.

A frequent symptom in this group of middle-ear affections is the Paracusis Willisii, *i.e.*, the ability to hear better in a noise (in a coach and during loud music). While this phenomenon has been recently attributed to the increased excitability of the auditory nerve produced by the concussion (Löwenberg, Urbantschitsch), I am of the opinion that the improvement in hearing in a noise is due to the movement of the inflexible auditory ossicula, so that they are placed in a more favourable condition for the conduction of the waves of sound. That at the same time the endings of the auditory nerve are set in vibration, producing an increased sensibility I have already described (Otolog. Congress in Milan, 1880). I first proved experimentally that in two-thirds of the cases where hindrance to sound-conduction, due to middle-ear affection, was present, by setting a vibrating low-toned tuning-fork upon the vertex a more or less marked increase in hearing occurred. This increase in hearing occurred also in many cases, according to my examination, if the cranial bones were set in motion by some rapidly vibrating body which produced no tone. In these cases the effect of a tone or noise upon the auditory nerve cannot be considered. In support of the view brought forward by me is the fact that in the evident cases of nervous deafness (without middle-ear affection), the paracusis Willisii is not observed. The latter, which Urbantschitsch believes is a condition also normally present, is in no ways proved by physiological experiment.

The perception through the cranial bones may be normal; often, however, it is diminished or completely absent. It disappears at an early stage most frequently in those insidious or inveterate forms which are accompanied by continual tinnitus; in hereditary processes, in general syphilis and in reduced cachectic individuals. The testing by means of the tuning-fork generally gives the results which have been described in middle-ear catarrh (*vide* Diagnosis).

Concerning the results of auscultation in the adhesive processes, I would refer to the description as given in the general portion (p. 107).

Course and Result.—The varied forms of adhesive middle-ear inflammation display such great variety in their progress that we must confine ourselves to a general description of them. As the development of the disturbances of hearing is the main point at issue, it will form the principal subject of the following exposition.

The development of the disturbances of hearing during catarrhal adhesive processes exhibits in the majority of cases a progressive character. This can be explained, if we consider that the products of disease in the middle ear, and often those in the labyrinth, do not continue in one stage of development, but in course of time undergo further alterations, by which the functions of the organ of hearing are still further impaired.

The progress of the deafness depends, therefore, principally upon retrogressive alterations (contraction, calcification, ossification), which are taking place slowly or quickly in the middle ear, and on the participation of the labyrinth sooner or later in the diseased process. While in a number of cases, therefore, only a gradual diminution in the power of hearing is perceptible in the course of many years, yet frequently we meet with those very bad forms where in a surprisingly short time, even in a few weeks or months, great and incurable deafness is developed.

The decrease in the power of hearing in the adhesive processes is seldom a steady one ; often during the course of the disease intervals of different duration occur, in which the deafness either remains stationary, or slight improvement may occur. Such shorter or longer cessation may be followed by a gradual or fitful decrease of the hearing-distance, until the deafness has either reached a degree which will rarely be altered, or has become absolute.

Complete deafness is on the whole rare. It develops either gradually and without marked symptoms, or suddenly by the intercurrence of a labyrinth affection with severe noises, dizziness, and fulness of the head; sometimes, however, without any of the accompanying symptoms. The most frequent causes of such permanent or transient deafness I have mentioned: catching cold, the effect of loud noises, concussion of the head, mental effects, excesses, brain and spinal cord diseases, syphilis, and old age.

A curious course is taken by those insidious interstitial inflammations of the lining membrane of the middle ear, limited to the pelvis ovalis, which so often result in anchylosis of the stapes. The affection commences often with slight but gradually increasing subjective

noises, which exist for a long time without noticeable deafness, and are often taken for so-called nervous tinnitus, until, after many years, the commencement of the decrease in hearing is apparent. The deafness which is developed from that point progresses irresistibly with but occasional pauses until it reaches a very high degree or becomes complete. The subjective noises are almost always a constant symptom of this form, generally very severe and annoying. The commencement of the disease is usually often overlooked. The patients only become aware of their ear disease when the deafness makes itself felt in ordinary intercourse; indeed, it not seldom occurs that the patient, before he himself has an inkling of the defect, has his attention drawn to his deafness by his friends.

In the greater number of cases in which anchylosis of the stapes was observed post-mortem, I found from the history of the patient that the decrease of hearing occurred after the existence of subjective noises for ten or fifteen years, and the progressive increase of deafness was only very gradual. In these cases there was generally a marked negative Rinne, with sometimes lengthened and sometimes diminished duration of perception through the cranial bones; the latter especially when the disease had existed for a long time and in old age.

In contradistinction to these insidious adhesive processes in the pelvis ovalis are those which undoubtedly are complicated with labyrinth disease. They show a malignant course, generally ending with anchylosis of the stapes, and progress so rapidly that after a short duration of the disease, even after some weeks or months, conversation at a short distance is difficult. They are accompanied by subjective noises and decrease of cranial bone perception, and generally result from hereditary predisposition, anæmia, scrofula, tuberculosis, or constitutional syphilis. In the latter the deafness occurs simultaneously with other secondary appearances on the skin, the mucous membrane of the pharynx or on the bones, or it may develop a long time after the disappearance of all other secondary symptoms as an isolated syphilitic disease of the ear. Decrease or disappearance of the perception for the watch and acoumeter and marked shortening of the duration of perception through the cranial bones are especially marked in this form.

As specially important for the development of high degrees of deafness in the adhesive middle-ear process, I would refer to the fact that when in a case of unilateral middle-ear affection the power of hearing of the affected ear is either reduced to a minimum or wholly extinct, the tendency of the normal ear to become diseased is thereby considerably increased. Experience shows that when

in unilateral deafness the previously normal ear becomes diseased, the deafness in it does not develop gradually, but usually very rapidly, and that in a short time the second ear often becomes more deaf than the one which had been affected for years.

Having so far considered only that overwhelming majority of cases in which during the course of chronic adhesive processes the deafness continually increases, it must be added that cases sometimes come under observation where, even after many years' duration of the affection, a decided improvement in the hearing spontaneously takes place. This either lasts for a long time, or sooner or later another change for the worse takes place. The spontaneous improvement is caused in such cases either by the partial decay and absorption of new-formed tissue in the vicinity of the ossicula, or in the disappearance of an abnormal tension in the sound-conducting apparatus.

Lastly, it may be mentioned that sometimes in the course of so-called dry catarrhs, even after long duration, a serous or mucous exudation in the middle ear occurs; that further, sometimes a simple acute middle-ear inflammation, or an acute suppurative middle-ear inflammation with perforation, are intercurrent, and are accompanied by considerable change for the worse in the hearing. Such inflammations may either pass off without harm, or leave increased disturbance of the function. Only exceptionally do we observe an improvement in the hearing after the reactive inflammation.

Diagnosis.—The diagnosis of the adhesive processes in the middle ear is not difficult in those cases where marked alterations in the membrana tympani, as thickenings, chalky deposits, and contractions or partial atrophy, exist. These appearances in the membrane, when taken in conjunction with the course of the disease, the subjective symptoms, the result of the functional examination, and auscultation, will in most cases lead us to assume the presence of pathological alterations in the sound-conducting apparatus as the basis of the deafness. With a normal membrana tympani, however, or when it exhibits a slightly striated or diffused opacity, such as is often seen in persons of normal hearing, the diagnosis is more difficult, especially when the Eustachian tube is normally permeable.

The test with the tuning-fork will give a differential diagnosis between middle-ear and labyrinth affections in the larger number of cases (compare pp. 144 and 146). Weber's test is conclusive for the diagnosis of a hindrance to sound-conduction in the middle ear in unilateral affections only when the perception is lateralized in the diseased ear. In bilateral deafness of high degree the Weber test is of less diagnostic value than the Rinne. Marked

negative Rinne with accompanying failure of perception for the lower tones and lengthened perception for the tuning-fork through the cranial bones are the most positive diagnostic signs of a hindrance to sound-conduction in the middle ear. If advanced labyrinth disease complicates the middle-ear affection, the Rinne test gives no certain result, as the tuning-fork may neither be heard before the ear nor on the mastoid process. That a marked diminution of the duration of perception for the tone of the tuning-fork through the cranial bones (in persons under sixty years) makes a complication with labyrinth disease probable has already been mentioned.

High tones are relatively better heard than low, yet the perception for the highest perceptible tones is often diminished; and one frequently observes in the upper portion of the scale, more rarely in the middle portion, failure of perception for certain tones which undoubtedly depends upon an accompanying change in the labyrinth.

We shall now discuss the diagnosis of adhesions between the membrana tympani and the deeper parts of the tympanic cavity, as also the determination of anomalies of tension of the sound-conducting apparatus. The diagnosis of adhesions of the membrana tympani is possible by inspection of the membrane during inflation or by examination with Siegle's speculum. Thinned parts of the membrane, which lie closely applied to the internal wall of the tympanic cavity, or to the incudo-stapedeal articulation, bulge forward like bubbles after an inflation, and show marked movement upon testing with Siegle's speculum. The bulged-out parts either remain some time in this position, or quickly collapse. Very concave membranes may often be seen to sink back quickly after inflation. Where synechiæ exist, however, the sunken adherent places remain unaltered, as well with the air-douche as upon testing with the pneumatic speculum. If an examination with Siegle's speculum be made, the non-adherent parts of the membrane show a distinct movement as condensation and rarefaction of the air alternate in the external meatus, while the adherent places remain quite unmoved. Bridge-like fibres between the membrane and the internal wall of the tympanic cavity cannot be diagnosed by this method, because the parts of the membrana tympani concerned possess some mobility, as I have been able to convince myself by post-mortem examinations.

The anomalies of tension of the membrane cannot be determined by inspection alone, it being often found that an opaque, much retracted, and apparently tense membrane turns out on examination with Siegle's speculum to be highly flaccid, while sometimes a normal-looking membrane when similarly examined proves to be tightly stretched.

Inasmuch as slight changes in tension cannot be diagnosed with the pneumatic speculum, and we can only judge of marked diminished movement of the membrane or a portion of it from excessive tension, only in excessive movement may we conclude as to a flaccidity of the membrana tympani. A marked movement of the handle of the hammer precludes an anchylosis of this ossicle and also of the incus. In anchylosis of the incus the movement of the malleus is also diminished. The important clinical fact should here be mentioned that occasionally in tightly stretched, more often, however, in flaccid membrana tympani, and also with marked retraction

of the handle of the malleus, only a slight defect of hearing is observed. One must conclude, therefore, that changes in the tension of the sound-conducting apparatus may exist within certain limits without marked disturbance of function.

To diagnose an anomaly of tension in the membrana tympani, Lucae recommended blowing lightly into the external meatus through a rubber tube 3 cm. in diameter, which is introduced $\frac{1}{2}$ cm. into the meatus. In retraction of the membrana tympani with increased tension the noise of the air will be markedly higher in pitch. This method, which requires an educated ear for distinguishing fine differences in tone in the examiner, can only be used in unilateral ear affections, so as to compare both ears. Löwenberg (Congrès Otolog. Internat., Paris, 1889) has constructed a very delicate apparatus to determine the difference between the normal and pathological membrana tympani, in which it is possible to read the degree of tension of the membrana tympani from the apparatus.

Prognosis.—As we have to deal in adhesive processes of the middle ear with products of disease which have become organized, a complete return to the normal state is of course out of the question.

The prognosis is therefore confined to probable conclusions from the course of the disease and its accompanying symptoms, whether in its further course the disturbance of hearing will increase slowly or quickly, and whether a substantial or only a trifling improvement in the hearing may be expected from the treatment to be applied.

The affections which originate in secretive catarrhs have, as a rule, a more favourable prognosis than the insidious circumscribed inflammations, which are often complicated by an affection of the labyrinth.

The prognosis is relatively more favourable if the disturbance of hearing is not yet of a high degree, although the disease has been of long duration; also if it has run its course without subjective noises, or if their occurrence has been only temporary; and if the power of perception of the auditory nerve through the cranial bones is still normal. The prognosis will also be more favourable if a marked improvement in the hearing, and a lessening of the tinnitus, are observable after the injection of air into the tympanic cavity.

On the contrary, the prognosis is an unfavourable one in cases where, after a short duration of the disease, a considerable disturbance of hearing has already become developed without any free exudation in the middle ear being traceable, or where the difficulty in hearing, irrespective of the duration of the disease, has already reached a very high degree, and where increase in the hearing-distance is either imperceptible or very trifling, after the injection of air into the middle ear. The prognosis is also more unfavourable in cases where with a

normal state of the membrana tympani, and a normally permeable Eustachian tube, the process has a steadily progressive, insidious character, where the subjective noises continue uninterruptedly, and the faculty of perception through the cranial bones is either lessened or has quite disappeared. A rapid decrease in the function of hearing may especially be expected in those cases where perception through the cranial bones is wanting after only a short duration of the disease.

The prognosis of chronic adhesive processes in the middle ear is also unfavourable in old people, and in the various general diseases, as scrofula, anæmia, tuberculosis, marasmus, cachexia. An undoubted hereditary tendency and vicious external conditions of life, such as occupation, have also a decided influence upon the prognosis.

Treatment.—As adhesive inflammation of the ear does not admit of a complete restitution of the function of hearing, it must be the task of the surgeon not only to improve the power of hearing as much as possible, but also to stay the rapid progress of the disease, and to mitigate the tormenting subjective noises as well as the troublesome head symptoms which accompany the disease in the ear.

Injection of Air into the Middle Ear.—Much less improvement in hearing is produced by the injection of air into the middle ear in adhesive processes than in secretive catarrh. Experience shows, on the whole, that relatively the best results may be obtained by the author's method. The result of injecting air by means of the catheter is less favourable, and it is only in greater obstruction of the Eustachian tube that the air-douche by means of the catheter produces a more marked improvement in hearing, as well as greater easing of the subjective symptoms than this method.

For this reason, in those cases where catheterization is possible, both methods should be used, to see which method, in respect to the increase of hearing, is indicated in this special case. The strength of air pressure used must be regulated in these processes according to the obstructions in the Eustachian tube, and the degree of tension of the membrana tympani. When the membrane is flaccid and the tube permeable, only a slight amount of pressure should be used; on the other hand, marked obstructions in the middle ear require greater pressure of the current of air. Where, after using the air-douche several times, a change for the worse is noticed, it should be immediately stopped. The air-douche has the most unfavourable effect, in whatever manner used, upon those scleroses of the mucous membrane of the middle ear with rapidly increasing deafness, and in the hereditary form of dry catarrh.

The improvement in hearing following the air-douche is dependent on the pathological changes present in the middle ear, on the extent of the anomaly of tension in the sound-conducting apparatus, and upon the participation of the labyrinth in the disease process. If immediately after the injection of air a considerable improvement in hearing takes place, a better result may be expected from the treatment than in those cases in which the air-douche produces no appreciable improvement in hearing. A portion of the improvement in hearing after the air-douche disappears in most cases within twenty-four hours, and often only after its repeated use will a longer continuance of the improvement be noticed.

The decrease in hearing after the air-douche, which is seen in many cases, owing to an excessive tension of the membrana tympani, is quickly relieved by repeating the act of swallowing several times. In the treatment of adhesive processes the air-douche should not be used daily, but only every second or third day.

The estimates of the results of treatment of chronic catarrhs of the middle ear by compressed air in the so-called pneumatic cabinets are very different. Magnus, to whom we owe the most reliable information as to the conduct of the organ of hearing in compressed air (*A. f. O.*, vol. i.), and also v. Tröltsch deny that there is any value in this method of treatment. In the majority of the cases observed by me, the effect of sitting in the pneumatic cabinet could not be estimated, because, according to the statement of the patients, inflation after my method has been practised simultaneously. In cases where the patient was only exposed to the effect of the compressed air in the cabinet, the result was generally slighter than after the application of my method or of catheterization. In only a few patients could I observe a considerable improvement in the hearing after pneumatic treatment where formerly local treatment had been without results.

Medicinal Treatment.—The remedies are introduced into the middle ear either as vapours or in solution. It has been thought that drugs brought into contact with the lining membrane of the middle ear would dissolve the exudation deposited in the mucous membrane, and thus lead to its absorption. As we seldom have to deal with exudations capable of absorption in this group of the affections of the middle ear, but generally with new formations of connective tissue, it is clear that they cannot be made to disappear through the action of drugs.

Only in those cases in which, besides the new connective-tissue growth, a round-celled infiltration of the mucous membrane is present, can resorption occur through degeneration of the round cells.

The action of drugs in the adhesive processes can therefore be traced to the following facts :

1. As the introduction of vapour as well as the injection of small quantities of fluid into the middle ear is always effected by a certain pressure of air, the resulting improvement in the hearing must be attributed to a great extent to the simultaneous action of the currents of air.

2. The drugs introduced into the middle ear cause more or less irritation, by which the articulations of the ossicula, which have become rigid, are loosened. Thus the lining membrane of the middle ear is prepared for the action of the injected air as the loosened parts become more elastic.

3. In cases in which there is still swelling of the mucous membrane of the middle ear, owing to infiltration of cells, the unorganized cellular elements may still partly degenerate and be reabsorbed, from the irritation of the drugs.

*Injections.**—Injections of medicated solutions into the middle ear are now used much more frequently than vapours, in cases of chronic affection. Of the numerous solutions recommended for injection into the middle ear, must be mentioned: caustic potash, in the proportion of 1 in 400 (Pappenheim, Marc d'Espine, Schwartze); caustic soda, 0·5 in 30; lithium carb., 0·1 in 30 (v. Tröltsch); sal ammoniac, 0·5 in 40; chloride of sodium, 0·5 in 15; bicarbonate of soda, 0·5 in 10·0; borax 0·5 in 20·0; iodide of potassium, 0·5 in 15·0; nitrate of silver, 0·2 in 30·0; corrosive sublimate, 1·0 in 100·0 (Wilde, Toynbee); chloral hydrate, 1·0 in 30·0 (Bonnafont, Lucae, Wreden); acetic acid or lactic acid, 1-5 drops to 40·0 water; muriatic acid, 1-3 drops to 40·0 water.

The greatest reaction is caused by solutions of potash and soda, acetic acid, nitrate of silver, corrosive sublimate, sal ammoniac, chloride of sodium, and sulphate of copper (de Rossi).

Of the above solutions I have used in my practice for a number of years bicarbonate of soda chiefly (℞ sodæ bicarb. 0·5, aq. dest. 10·0, glycerine pur. 2·0). This solution acts very mildly, and very rarely causes much irritation of the mucous membrane of the middle ear and naso-pharynx. I have also seen favourable results in a series of cases after injection of 5 to 6 drops of a 2 per cent. pilocarpine solution into the middle ear. Following the injection often there is slight salivation and perspiration, especially in the diffuse chronic middle-ear catarrhs, in which slight swelling of the mucous membrane of the cavum tympani and tube is still present. On the other hand, the subcutaneous injection of pilocarpine in dry catarrh has proved quite worthless.† Ch. Delstanche (*Baseler Congresses-bericht*, 1883) reported good results from the employment of pure

* On the method of injection into the middle ear, see p. 108.

† A. Politzer, 'The Employment of Pilocarpine in certain Affections of the Ear, and the Abuses of this Remedy' (the *Lancet*, 1891).

ol. vaselini injected through the catheter into the middle ear. According to my experience, the sterilized and slightly-warmed vaseline oil is not followed by the slightest reaction, even when larger quantities are injected into the middle ear, and has a beneficial effect in many cases. Delstanche considers that in many cases adhesions in the cavum tympani have been separated by forced injection of fluid vaseline, and thereby a marked improvement in hearing produced. In the case of undoubted syphilitic affections of the ear, especially if the disease of the middle ear is accompanied with an affection of the labyrinth, I inject solutions of iodide of potassium, but their action must always be supported by general antisyphilitic treatment.

In the treatment of catarrhal adhesive processes by means of injections, all medicines which produce a severe reaction must be avoided. It cannot be denied that after a reactive inflammation due to injection, a noticeable improvement occurs for a short time. In most of these cases there follows later such a remarkable turn for the worse, that often in a few months the deafness is more marked than before the treatment. The same applies also for the injections of large amounts of fluid by means of Seamann's water-douche or Gruber's modification of it, the uncontrollable action of which has already been mentioned.

*Vapours.** — Medicated vapours, first recommended by Saissy, were formerly more frequently used in the treatment of chronic affections of the middle ear than at present. We will mention only those which have been recommended as particularly effective. They are: steam, sal ammoniac vapour, and the vapours of carbonate of ammonium (v. Tröltsch), iodine, iodic ether (Rau), acetic acid, acetone, pyroligneous acid and tar (Bonnafont); the vapours of turpentine, of different balsams and resins (Hubert-Valleroux), carbonic acid (Ruete) and hydrogen gas (Löwenberg). I have seen the relatively best results from the use of iodide of ethyl, as recommended by Burckhardt-Merian. I use chloride of ammonia and turpentine vapour only experimentally in persistent swelling of the tube where injections proved useless.

As regards the effects of injections and of vapours, as compared with simple inflation with air, I must from my experience declare that in the great majority of adhesive processes originating in catarrhs, the degree of improvement in the hearing which in any case may be obtained, could be procured by propelling air alone into the middle ear. In a number of cases, however, the effect of the inflation of air is undoubtedly much increased by the combined application of medicated solutions or vapours.

* On the method of introduction of vapours into the middle ear, see p. 111.

The question whether better cures are effected in the so-called dry catarrhs of the middle ear by the application of vapours or of medicated solutions, is still a subject of controversy amongst specialists. The fact is that, in the limited number of cases where any improvement is caused by a local medicated treatment, sometimes vapours and sometimes solutions give the more favourable result. On the whole, however, there is very little difference between the two methods, as in either case marked and permanent benefit is out of the question. Injections are so much more effective, in that the result to be attained can generally be achieved in a shorter time than by treatment with vapours. The more convenient method of injection, which takes less time (de Rossi) and is less troublesome to the patient, is generally to be preferred to the introduction of vapours. V. Tröltsch says that he has obtained good results from a combination of the two methods, by injecting an irritating fluid after applying steam for a short time.

When applying drugs, especially in solution, it is advisable to use injections and inflation of air alternately every other day, because treatment with injections alone often causes a change for the worse. When the medicated injections appear to have an unfavourable effect a return to the use of the air-douche alone is indicated. In some cases in which continuous subjective noises are present the following vapour (Liq. Hollandi, Æther acet., āā 5·0; Tinct. Iodine, 0·2), either used by means of the catheter or by my method, has proved of more benefit than medicated injections. Indeed, cases sometimes occur, especially in hereditary and malignant forms of scleroses, where every local treatment acts injuriously. Especially in cases where disease either of the membrana tympani or of the Eustachian tube cannot be proved to exist, and where the disturbance in the hearing is only a trifling one, I must caution against medicated treatment in these insidious inflammations of the middle ear.

The local treatment of the adhesive processes, especially those combined with anomalies of tension, is in many cases assisted by rarefaction of air in the external meatus (p. 124), for which the 'rarefacteur' of Delstanche is indicated and often has a good effect as regards hearing, tinnitus, and head symptoms. In order to measure the pressure of air used, and to avoid the ill effect of over-pressure, Suarez de Mendoza provided the rarefaction with a water manometer, by which the pressure is recorded in $\frac{1}{100}$ to $\frac{1}{1000}$ of the atmospheric pressure. According to this author one should begin with from $\frac{2}{100}$ to $\frac{3}{100}$ atmospheric pressure and gradually increase to $\frac{15-20}{100}$.

In a similar manner the 'masseur' of Delstanche, by alternately condensing and rarefying the air in the external meatus (massage), very often produces a beneficial result in catarrhal adhesive processes. Bing uses an olive provided with a valve to continue the rarefaction of air for a longer time. This is provided with a short tube hermetically placed in the external meatus, and the air is aspirated by the mouth. After the aspiration the valve is closed by the air-pressure, by which means the rarefaction of air may be continued for half an hour to one hour.

Lucae recommends for the mechanical treatment of adhesive processes a feathered sound, by which a repeated pressure may be brought to bear upon the short process of the malleus and a decrease of the excessive pressure in

the sound-conducting apparatus produced. This very painful procedure is often followed by a remarkable improvement in hearing and decrease of the subjective noises. This usually disappears, and only in rare cases is a permanent improvement observed. For this method alone, without at the same time treating the middle ear through the tube, a very slight result is obtained.

The results of local treatment depend in the first instance on the nature of the pathological alterations in the sound-conducting apparatus, on the condition of the expansion of the auditory nerve in the labyrinth, and also on the facts which have been enumerated in speaking of prognosis, and which have a favourable or an unfavourable influence upon the course of the disease. The most remarkable is the increase in the hearing-distance in those adhesive processes originating in catarrhs, where a moderate swelling still exists, or where such anomalies of tension had been produced in the sound-conducting apparatus by the diseased process as are capable of partial removal by local treatment. But in cases of tight or but slightly flexible adhesions, or of complete anchylosis of the ossicula, of tight stricture of the Eustachian tube, and also in all cases where the condition in the middle ear is complicated with an affection of the labyrinth, the curative effect will of course either be trifling or nil.

The degree of the improvement of hearing to be obtained cannot be predicted. Where the deafness is not great, and where a noticeable increase in the hearing takes place after inflating the ear once or twice, as a rule a better result may be expected than in cases where the function of hearing has already considerably deteriorated, and where no alteration in the power of hearing, or only a slight one, is noticeable after the Eustachian tube has been made permeable. In general one must be cautious in the prognosis as regards the results of treatment, for occasionally only a very small amount is accomplished by treatment, when the general results of examination led one to expect a much better result, and, on the other hand, in cases which do not promise much, an unexpected improvement sometimes takes place. It often occurs that in cases where both ears are affected the power of hearing of the more affected ear is so improved by the treatment that it surpasses that of the previously less affected ear. Complete deafness for speech does not preclude the possibility of improvement in the hearing, as I have often observed, in cases where both ears were affected, and where the power of hearing for speech of the one ear had quite ceased, an improvement in hearing of the deafer ear to the extent of 1 meter occurring during treatment.

As previously remarked, the duration of the treatment is of great importance in regard to the result. In most cases a change for the worse takes place by too protracted treatment. It must therefore be continued only so long as a steady increase in the hearing-distance can be traced. If, therefore, after treatment for several weeks a cessation of improvement is observed, which continues in spite of continued inflation of air and injection of solutions,

the treatment must be stopped, because, if persisted in, the improvement in the hearing already attained will quickly disappear again. The length of time it takes to arrive at the best possible result varies much; in most cases it ranges between two and six weeks, but there are cases, though few, where it is only after treatment for three or four months or more that the greatest improvement in the hearing is reached.

During treatment the increase in the power of hearing is most striking during the first six or eight days, and only slight during the further course. More rarely, however, there is no essential improvement in the hearing noticeable until after treatment for several weeks.

With the increase in hearing the local treatment often produces a remarkable improvement of the subjective noises and annoying head symptoms; but the subjective noises may remain unaltered, however, in spite of the improvement in hearing. One observes occasionally as the only result of local treatment a disappearance of the head symptoms, and of the psychical depression.

I have already mentioned that in unilateral deafness of a high degree the predisposition to disease of the other ear is very much increased. For this reason the occasional treatment of unilateral middle-ear affections is very important. If it is possible to improve the hearing of the affected ear, and prevent complete deafness, the normal ear will not be affected so easily as when the function of the diseased ear has been completely lost.

The improvement in the hearing which results from treatment in the adhesive processes is rarely a lasting one. In most cases there is a decrease in the hearing-distance observable a few months after treatment.

From this the necessity of an occasional after-treatment will become apparent to counteract the rapid progress of the disease. This consists either in occasional repetition of the method of treatment previously described, where injections and inflation of air are applied alternately, or in the exclusive application of inflation of air from time to time. Indeed, experience shows that in many cases where, previous to the employment of treatment, a steadily progressive decrease in the hearing was observable, a repetition of the treatment once or twice a year had as its result either a stationary condition of the power of hearing, or a less rapid progress of the disease.

The most simple method for an after-treatment is my method of propelling air into the middle ear. Where circumstances do not permit its execution by the doctor, the patient can apply it himself,

after having been carefully instructed. A rapid decrease in the power of hearing and an increase of the subjective noises may often be brought about by its too frequent application. It is expedient to continue the inflation of air two or three times a week for five or six weeks, after which an interval of one, two, or three months must take place, the length of which must depend on the duration of improvement, for when a decrease in the hearing is noticed the air-douche should be repeated in the same manner.

In regard to the use of Valsalva's method, which is recommended by many ear specialists for the after-treatment, my experience is very much against it. As by this easily carried out procedure a momentary improvement in hearing is produced, the patient uses it a great many times during the day. The oftener the Valsalvan method is used, so much less will be the increase in the hearing-distance and the shorter the duration of the improvement, until after the misuse of this method for a long time a high degree of deafness results. It is therefore the duty of the physician to warn the patients of the bad results following the misuse of this method. In the same manner the patient should be warned against the misuse of catheterization and of the air-douche according to my method, as well as the rarefaction of air in the external meatus and the massage of the ossicles.

But while, through the above-described methods of treatment and a rationally instituted after-treatment, a stationary state for a number of years is in many cases produced, local treatment often remains without any result whatever in affections of the middle ear belonging to this group, as the affection progresses irresistibly till, in spite of treament, deafness of the highest degree has been reached. The hereditary insidious inflammations of the middle ear, combined with constant subjective noises, are the most common cases in which all treatment proves useless. Indeed, it may from experience be affirmed with certainty that in a number of cases, especially with anchylosis of the stapes, the unfavourable course is even accelerated by the local treatment, a fact which deserves full consideration in the treatment of chronic affections of the middle ear.

The Constrictions of the Eustachian Tube and their Treatment.—The narrowing of the canal of the tube following middle-ear catarrh is produced either by swelling of the mucous membrane or by new connective-tissue growth in the sub-mucous layer of the mucous membrane which goes on to shrinking and stricture of the canal. The latter are known as the true organic strictures of the canal.

The narrowing produced by swelling occurs either alone or from a catarrh of the tube extending from the naso-pharynx as well as in the secretive form of middle-ear catarrh. The connective-tissue strictures are usually the result of diffuse chronic middle-ear catarrh

which is often complicated with chronic hypertrophic catarrh of the naso-pharynx or with ozæna. Besides these, the canal of the tube may be narrowed by pressure of new growths in the naso-pharynx and on the base of the skull; and a relative narrowing, with impermeability, may be produced by inspissated crusts of mucus (Löwenberg) in the canal of the tube.

The site of the constriction is more often in the cartilaginous than in the osseous portion. The osseous portion may be constricted by hyperostoses of its walls, through bulging of its anterior inferior wall on account of the carotid canal, by extensive growth of the canal pro. tens. tymp. at the expense of the osseous tube (Zuckerkandl) through hypertrophy of the mucous membrane, granulations and cicatrices at the ost. tymp. In the cartilaginous portion the constrictions occur in the region of the isthmus at the junction of the osseous and cartilaginous portions, at the lower portion of the tube, and the ost. pharyng. tubæ, at which the constriction is caused by swelling. In constrictions of the canal caused by swelling, besides the intumescence of the mucous membrane, there is glandular hypertrophy folding and the growth of granulations on its surface. The connective-tissue strictures which result from this process generally occur in the middle portion of the cartilaginous tube in the region of the isthmus, often in the isthmus itself, more rarely in the lower portion where strictures or atresias of the ostium pharyng. occur after ulcerative processes extending to the tube from syphilitic or variolous ulcers of the naso-pharynx. Abscesses at the ost. tymp. tubæ I found most frequently in the chronic middle-ear suppuration following the formation of granulations.

The narrowing of the tube is generally accompanied by a high degree of deafness and severe subjective noises, although the latter may be quite wanting in severe strictures. A feeling of fulness and pressure in the ear, which is described by other authors, occurs in true strictures very rarely; often, however, in the slighter degrees of swelling of the tube. Annoying head-symptoms and occasional attacks of giddiness are frequent in organic strictures. The membrana tympani appears, especially in the secretive and swollen condition of the middle ear, strongly depressed; in the connective-tissue narrowing, on the other hand, the concavity is often not altered.

As regards the auscultation sounds in narrowing of the tube, we have already mentioned that in the swollen condition of the canal generally, a sharp, high, snapping sound is heard, occasionally accompanied by a mucous rale. In the connective-tissue strictures, however, the noise is entirely wanting, or it is indistinct, scarcely noticeable, and unchanged by the act of swallowing. Occasionally there occurs during the passage of air through the narrowed portion a high, hissing, whistling, and snapping sound; there is also, as in

all constrictions, a marked resistance in the balloon upon pressing the air in. It has already been stated that in the greater obstructions of the canal, inflation by means of Valsalva's and my methods is often not successful.

The *diagnosis* of stricture is made from the marked obstruction to pressing air into the cavum tympani through the catheter and the slight influence of the act of swallowing upon the abnormal auscultation sound in the higher degrees. Bougieing very often gives a signification as to the condition of the tube, but hindrances to it are not sufficient for the diagnosis of a stricture, as the point of the bougie—even under normal conditions in congenital angular bending of the canal, or through the formation of folds in the tube—may be prevented from proceeding farther while auscultation shows a free entrance of air into the ear. In most middle-ear catarrhs without narrowing of the canal, one observes, after the bougieing, a freer entrance of air than before. The auscultation only gives an important point for the diagnosis of stricture of the tube, if after the bougieing a much freer entrance of air, by means of catheterization, is noticed, that is, if a great difference between the auscultation sound is noticed before and after the bougieing.

The treatment of stricture of the tube is varied according to the anatomical foundation and the amount of the narrowing. In the swollen condition of the canal the treatment is combined with that of the middle-ear catarrh. In many cases a lasting widening is produced by the simple air-douche, and the high-pitched rubbing auscultation sound changes in the course of the treatment to a free full sound.

Obstinate strictures, produced by swelling, are sometimes removed by the repeated application of the bougie, and followed by the air-douche through the catheter, or by my method. But in some cases an increased swelling will be caused, and a decided aggravation of the symptoms produced by the mechanical irritation of the bougie. I sometimes use, in cases of stricture due to swelling, a thin rubber capsule instead of the bougie, 4 mm. long and $1\frac{1}{2}$ wide, which is fastened to the top of the catheter by a thread. After the insertion of the instrument into the tube the capsule is inflated through repeated pressure of air into the catheter. In consequence of the lateral pressure the vessels of the mucous membrane become compressed, and through the continued diminution of the quantity of blood in the mucous membrane of the tube a more rapid reduction of the swelling is produced. In cases of severe swellings, the introduction of catgut bougies saturated with argentic nitrate into the Eustachian tube sometimes proves very effective.

Where in spite of the methods of dilatation previously mentioned the symptoms of tubal constriction do not disappear, or where, by the first examination, an organic stricture is diagnosed, the introduction of a bougie into the Eustachian tube is advisable for a completion of the diagnosis and for the mechanical dilatation of the Eustachian tube.

For bougieing the Eustachian tube I use at present the brownish bougies of silkworm-gut (crin de Florence), which are conical in shape and are carefully rounded and slightly club-shaped at the point, with a thin lacquer covering. They possess a certain pliancy but sufficient resistance to pass through the Eustachian tube. For severe constrictions these bougies are seldom sufficient, for when they arrive at the stricture they bend back and slip into the throat. For bad strictures I use the whalebone bougies which were recently recommended by Dr. Suarez di Mendoza, and are manufactured by Mathieu in Paris. They are well polished and rounded and, in consequence of their greater resistance, slide more easily through the constricted portion. The point is either conical, olive-shaped, or cylindrical. Each series contains eleven bougies, whose diameter at the point varies from 0·4 mm., 0·5, 0·6, 0·7, etc., to 1·0 mm., these numbers being sufficient for the progressive dilatation of the stricture. The bougies with olive-shaped tips are used more for diagnostic, the cylindrical and conical more for therapeutic, purposes. Catgut bougies are particularly suited for the rapid enlargement of the stricture on account of their rapid swelling and also as medicated bougies, for which purpose the tip should be soaked in a solution of zinc sulphat., argill. acet. or nitrate of silver, and carefully dried.

In bougieing the following cautions are to be observed. A short catheter with a somewhat longer and a more strongly curved beak should be used, so that the point penetrates as deeply as possible into the Eustachian canal. By this means the return of the bougie into the throat will be prevented. In order to pass the strictured place, the bougie, being before its introduction dipped in vaseline oil, must be pushed forward to the ostium tymp. tubæ, which would be 1½ to 2 cm. beyond the mouth of the catheter. Several ink or colour marks at the end of the bougie serve to control the advance of the same and to determine the amount of projection beyond the point of the catheter. The catheter will be held fast in its place by the bougie.

The pushing forward of the point of the bougie into the tympanic cavity is useless, and by the use of resistant bougies may lead to the piercing of the membrana tympani, when the instrument will appear in the external meatus (Voltolini). In one case immediately after the application of the bougie sudden deafness was observed, probably in consequence of the dislocation of the ossicula.

The resistance met with by the bougie in the Eustachian tube is easily overcome in cases of slight stricture. If the constricted portion be short, the bougie will often pass the narrowest point with a jerk. But if the stricture involves a greater portion of the tube, considerable resistance will make itself felt during the advance of the

bougie, which can only be overcome without danger if the bougie be pushed forwards slowly with great caution and with occasional rotations round its axis (v. Tröltsch). In such cases it is often possible, after four or five sittings only, to pass the narrowest place by a careful and slow advance. The patient's sensations, even though not reliable in all cases, are important; he complains of a marked stinging sensation in the ear, sometimes in the teeth and in the occiput (v. Tröltsch), when the point of the bougie passes through the Eustachian tube, while in cases where it returns to the throat by bending, stinging is felt in the lateral region of the neck.

To effect dilatation, the bougie must remain in position for five, ten, or fifteen minutes. While passing the bougie—more often, however, upon removing it—a crackling sound is audible which, if not always, yet generally, may be looked upon as a sign of the successful application of the bougie.

If after repeated applications of the bougie no noticeable enlargement of the canal of the tube is seen, Suarez di Mendoza's proposition of progressive continuous dilatation of the Eustachian tube is indicated, by means of the so-called 'bougie à de meure.' For this purpose Suarez di Mendoza's ingeniously constructed metal catheter is used, which is divided into two parts lengthwise. After the introduction of the bougie, one part of the catheter is first removed from the nose, then the bougie is lifted out by gentle lateral pressure of the now open second half, which is also removed. The projecting piece of the bougie is cut off close to the nostril, and remains twenty-four hours in the tube.*

Flexible bougies, after having been removed from the Eustachian tube, often present at their end a curve corresponding with the form and direction of the stricture. If catheterization is resorted to immediately after extraction of the bougie, the air is heard to enter the tympanic cavity in a much fuller current than before. Marked subjective relief often ensues, as also a decrease in the tinnitus and a considerable improvement in the hearing. With such favourable results it is always advisable to repeat the manipulation twice or three times weekly, introducing progressively thicker bougies, and to continue the dilatation till the air enters the tympanic cavity during catheterization or Politzerization without noticeable resistance.

The results of mechanical dilatation of the strictured Eustachian tube are not, on the whole, very good. Cases of striking and lasting improvement in the hearing where, after years, no recurrence of the

* *Contribution à l'étude du diagnostic et du traitement des obstructions de la trompe d'Eustache*, par le Dr. Suarez di Mendoza. Congrès Internat. Otolog. Paris, 1889.

stricture takes place are very rare, and it is probable that many of the cases of cure of stricture of the tube which have been recorded were strictures not due to the formation of connective tissue, but simply to swelling of the Eustachian tube, which was capable of resolution. In the majority of cases the stricture recurs, with a corresponding decrease in the hearing-distance gained, and an increase of the subjective noises. If the treatment by dilatation be renewed, an improvement in the hearing usually occurs, but very rarely to the same extent as before. The result will be still less favourable with later attempts at dilatation, in consequence of the tissue changes in the tympanic cavity. Nevertheless, in cases of undoubted narrowing of the tube, I look upon the introduction of bougies as very important, because some improvement takes place in the hearing, the often unbearable subjective noises are toned down, and the rapid progress of the disease is also prevented. It must, however, be mentioned, that in many cases no dilatation is effected, in spite of long-continued attempts, and that often neither an increase in the hearing nor a decrease in the tinnitus takes place, in spite of a successful dilatation.

It is also observed in a number of cases that by the application of the bougie an aggravation of the local trouble is produced: increasing impermeability in cases of swelling, decrease of hearing, and increase of the subjective noises; and it is therefore necessary to control the effect of the application of the bougie in the course of treatment.

Starting from the observations already made by Weber-Liel that the simple introduction of a bougie into the canal of the tube suffices in order to effect a passing improvement in the hearing, Urbantschitsch proposes the application of the bougie in those cases in which there is no contraction of the tube. There appears frequently in cases of catarrh swellings, as well as in cases with a normal pervious tube, an improvement in hearing and a decrease of the noises by pushing to and fro a bougie provided with a bulbous point.

As this improvement depends, according to Urbantschitsch, upon a reflex in the auditory centre produced by the irritation of the sensitive branches in the tube, its action is transient, as all such reflexes are. That unpleasant sensations, decrease in hearing, and middle-ear inflammations, may be produced by bougieing, is known from the experience of the ear specialists. I limit my use of the bougies to those cases in which a constriction of the tube is diagnosed from the objective examination and where other means fail to remove it. In two cases with considerable stricture in the region of the mouth of the tube, I succeeded by means of electrolysis, as recommended by Mendoza and Baratoux, in restoring the passage of the tube. I used a metal wire, provided with an olive-shaped tip, and introduced through the catheter with a current of 5 milliampères. Further observation is necessary to see if these dilatations of the tube are permanent.

The treatment of the naso-pharyngeal affections accompanying middle-ear catarrh will be spoken of in detail in a special portion of the book.

In the treatment of middle-ear catarrh, the patient's surroundings and the condition of the general health must be taken into consideration. This applies to the secretive form, as well as to adhesive processes and chronic middle-ear suppuration. The patient should avoid all detrimental influences of occupation and business, and also unfavourable dwellings (ill-ventilated and damp houses) as much as possible. Frequent airing of the rooms, the avoidance of close, smoky localities, and exercise in the open air in good weather should be strongly recommended to the patient. The diet should be regulated according to the habits of the patient, especially wine and beer, which should be limited to a moderate quantity, and only a slight amount of smoking allowed, especially when these things have a detrimental effect on the deafness and tinnitus. Warm baths once or twice a week often have a favourable influence upon the course of the secretive catarrh. They also often have a favourable influence upon the chronic adhesive forms during the local treatment: probably on account of the relaxing effect upon the mucous membrane of the middle ear by means of the warmth. On the contrary, cold baths and sea baths often produce an aggravation of the condition, and patients should be warned regarding the bad effects of cold head douches, and diving while in the bath. In the chronic catarrhal adhesive processes the bad effect of hydropathic treatment is not as frequent as generally supposed, for in many cases sea baths and salt-water cures have a beneficial effect upon the hearing and subjective noises. The cold-water cure has certainly a bad effect in uræmic, decrepit individuals, and in the hereditary and insidious adhesive processes of the middle ear.

Change of air and remaining in a mountainous region has a very favourable influence upon the course of the secretive form of catarrh. I have often seen complete healing in cases which had received local treatment for months without effect, upon leaving the city and remaining several months in an Alpine region. The air of a high locality has sometimes a remarkably good effect even in chronic cases. The persistent cases, especially in weak, anæmic and scrofulous individuals, when their circumstances allow, should be ordered at the beginning of warm weather to go to a woody or mountainous region. In the adhesive processes, changes of air and climate have no marked influence upon the course of the disease. These cases should be recommended to spend the colder portion of the year in a southern climate, especially if in a northern climate they are

subject to naso-pharyngeal catarrh from which they are free in the south.

If there is a constitutional disease, it is better to combine a bath and water cure with the sojourn in the country. For scrofulous persons the salt and iodide baths of Ischl, Kreuznach, Hall, Lippik, Iwonicz, and Bourbonne, are specially suited; for anæmic persons the iron springs of Franzensbad, Marienbad, Spaa, Pyrmont, Szliács, and also the waters containing iron and arsenic of Roncegno and Levico are suitable. Specially indicated in abdominal congestion are the waters of Kissingen, Carlsbad, and Vichy; in rheumatism, Wiesbaden (Pagenstecher); in constitutional syphilis especially the known iodide baths and also the sulphur springs near Vienna, Aachen, and Pystjan.

Internal and External Medication.—The internal treatment of the adhesive processes, to which some aural surgeons attach much importance, is of little value, if those cases are excepted in which a constitutional disease is present. In constitutional diseases, however, the good effect of internal treatment on the course of the aural affection cannot in many cases be denied. In general syphilis, the local treatment of the aural affection must be combined with mercurials or iodine, as required; in scrofulous cases, the internal administration of the iodide of potassium or of iron is necessary; and in anæmic, debilitated patients, the more soluble preparations of iron must be prescribed. The internal treatment of the adhesive processes accompanied by labyrinth affections and rapid increase of deafness, as well as the treatment of the subjective noises accompanying these affections, will be described with diseases of the internal ear.

Externally, medicated applications in the vicinity of the ear, or in the external meatus, are almost altogether without effect. Painting the lining membrane of the osseous meatus with tincture of iodine and the inunction of iodine ointments over the mastoid process, much recommended even now, are found of just as little value, but may be used in pronounced syphilis.

The Operative Treatment of the Adhesive Processes.

1. *The Artificial Perforation of the Membrana Tympani.*

Historical.—Attempts at the cure of deafness by excision of a piece of the membrana tympani date from the seventeenth century; but the operation, which was performed without any certain indications, was hardly thought worthy of notice by the surgeons of the seventeenth and eighteenth centuries. The first scientific communications on the artificial perforation of the membrana tympani date from the beginning of this century. It was Himly

(1795) and Astley-Cooper who, independently of each other, performed the operation, and also recommended it strongly, being encouraged by the favourable results met with in the beginning. But however favourable these first results were, Cooper and Himly were convinced in a short time that the startling effects were only temporary, as the artificial opening in the membrane was almost always closed up by new-formed cicatricial tissue, and the former degree of deafness always returned.

Meanwhile the news of the brilliant results obtained by Cooper spread on the Continent, and while that surgeon, convinced of the uselessness of the operation, had quite abandoned it, it was long afterwards performed in France and Germany with unexampled zeal in hundreds of aural cases. Himly deserves credit for at last putting a stop to this operation, performed to the injury of so many aural patients. By compiling the observations made by the trustworthy surgeons of that time, he proved that it was only in exceedingly rare cases that a slight improvement was obtained, while in most, where the operation was performed regardless of the pathological changes in the middle ear, of which little was known at that time, no improvement resulted.

The ill-success of the operation, and the impossibility of keeping the aperture in the membrana tympani open, were the reasons why this method was afterwards only rarely employed. In the beginning of the decade 1860-70 the operation was repeated without any new attempt to keep the opening in the membrana tympani patent, and the failures of Cooper and Himly were repeated.

Indications.—The chief object of making an opening in the membrana tympani is to form a passage for the waves of sound to the labyrinth, in all cases where their propagation from the membrana tympani to the stapes is impeded, and to remove the difference in air-pressure between the tympanic cavity and the external atmosphere.

The artificial perforation of the membrana tympani is used in chronic middle-ear catarrh, combined with severe deafness, as well for diagnostic as therapeutic purposes. The operation is therefore advisable: (1) in abnormal thickening, or extensive, firm calcification of the membrana tympani: (2) in fixture of the malleus and incus by immediate ligamentous union with the walls of the tympanic cavity; (3) in great irremovable strictures and adhesion of the Eustachian tube (Cooper); (4) in excessively loud subjective noises, if they cannot be alleviated by the methods of treatment already detailed; (5) to carry out intra-tympanic operations.

Through the artificial aperture in the membrane, the waves of sound, avoiding the membrana tympani, the malleus and the incus, can strike the footplate of the stapes immediately, and in this way be communicated to the labyrinth. The operation can therefore be immediately successful only when the stapes is still movable,

when the membrane of the fenestra rotunda is not thickened or calcified, and when no labyrinthine complication exists. A minute examination of the function before the operation is therefore an important preliminary condition for its performance. Perception for the ticking of a watch, and lengthened perception for the c^2 tuning-fork through the cranial bones, are very important conditions for the performance of the operation. Indeed, experience shows that the improvement in the function is but trifling in cases where perception through the cranial bones is weak or quite wanting.

Methods of Operation.—Of the numerous methods proposed for making an artificial opening in the membrana tympani, the older methods: excision of a portion of the membrane (myringectomy); excision of a portion of the handle of the malleus (Wreden's sphorotomy); the crucial incision, and cauterizing with nitrate of silver and sulphuric acid have been discarded,* and at present only the perforation with the galvano-cautery is used. A simple, angularly curved, pointed cautery suffices to make in a second an aperture in the membrane of the size of a hemp-seed. It is important for the success of the operation that the cautery should become red-hot at the moment the circuit is closed, because the operation will be very painful if it is gradually heated.

The circuit must be closed only when the cautery is in immediate contact with the membrane. The cauterization must last but a moment, because otherwise too much of the membrane would be destroyed. All pressure upon the membrane is to be avoided, as the point of the cautery might easily penetrate to the inner wall of the tympanic cavity, and cause an inflammation of its mucous membrane. To avoid, with more certainty, the cauterization of the mucous membrane of the tympanic cavity, it is best to choose the anterior or the posterior inferior quadrant of the membrane as the seat of operation, because those parts are farthest from the inner wall of the tympanic cavity, while cauterization behind the umbo must be avoided on account of the vicinity of the promontory.

The results of the production of an artificial aperture in the membrana tympani are, briefly, that in a number of cases, immediately after the operation, a striking improvement in the hearing and a decrease of the subjective noises occur, from which it may be inferred with probability that the stapes is movable, and that the membrane

* Schirmunski (*Berliner Congressbericht*, 1890) reported complete success in six cases after cauterizing the edges of a crucial incision in the membrane with chromic acid crystals.

of the fenestra rotunda is in a normal state. In other cases, where pathological alterations exist either at the two fenestræ or in the labyrinth, the functional disturbance will be only slightly, or not at all, altered after the operation.

But the favourable result is of only short duration, for almost without exception the opening is soon closed up again by cicatricial tissue, the hardness of hearing and the noises in the ear again attain their former degree, or are still greater than before the operation, and only in isolated cases does a decided improvement remain after the closure of the aperture.

The former experiments to keep an artificial wound in the membrane open by means of inserting catgut strings, whalebone pegs, lead wires, and silver cannulas (Bonnafont), have not succeeded. The method proposed by me, of introducing an eyelet of gutta-percha (Fig. 137), and the aluminium or gold cannulas, as recommended by Voltolini, which fasten to the handle of the malleus like a horseshoe, to prevent their falling into the tympanic cavity, have proved of very little more value. All of these devices were expelled, sooner or later, accompanied sometimes by suppuration, after which the opening cicatrized.

FIG. 137.—VULCANITE EYELET. (REAL SIZE.)

In spite of the numerous unsuccessful attempts, continued endeavours in this direction may in the end succeed. This supposition is founded upon the fact that apertures in the membrane which have been caused by pathological processes, especially by suppuration in the middle ear, very often persist during lifetime by their edges being covered with epidermis, and even in spite of freshening of their margins, cannot be made to close. The prevention of cicatrization of the artificial aperture might therefore be effected if the same conditions could be induced which lead to the perforation remaining open in pathological cases. According to my investigations it is probable that these are produced by the growth of the epithelium from the external surface of the membrane over the edges of the wound.

2. *Section of the Posterior Fold of the Membrana Tympani.*

Indications.—Section of the posterior fold was first recommended by me* (1871), and a year later by Lucae,† and is advisable in all cases where the objective signs of an abnormal inward curvature of the membrana tympani are present, where the inferior extremity of the handle of the malleus is therefore retracted abnormally inwards, and the short process of the malleus and the posterior fold of the membrane extending from it project strongly towards the external meatus (p. 285). If these changes are combined with a disturbance

* *Ueber Trommelfellnarben, Wiener med. Wochenschrift*, 1870.
† Langenbeck's *Archiv für Chirurgie*, vol. xiii., 1871.

of hearing of a high degree and loud subjective noises, which cannot be materially improved by the local methods of treatment already described, an experimental section of the posterior fold of the membrane is justifiable in such cases. By this operation the tightly-stretched posterior superior quadrant of the membrane, specially important for the conduction of sound, is relaxed, and by this means the handle of the malleus acquires greater mobility.

Operation.—For section of the posterior fold of the membrana tympani I use a small knife, rounded at its point, sharp-edged, with the blade fixed at an angle to its handle, or the lancet (Fig. 139) represented on p. 314. The section is made perpendicularly to the longitudinal direction of the fold from above downwards, and the most favourable place for the incision is either directly behind the short process or midway between the short process and the peripheral extremity of the fold (Fig. 138). The division of the fold is generally accompanied by a grating noise, the margins of the wound recede from each other, and the handle of the malleus, which was drawn inwards, assumes a more perpendicular position. The bleeding after the operation is generally trifling; sometimes it is considerable on severing the vascular bundle which extends from the membrana tympani to the upper wall of the meatus, but it can soon be arrested by applying a small plug of cotton-wool to the incision. This application is also advisable when there is only slight bleeding, to prevent crusts of blood forming on the membrana tympani. Sometimes the blood flows from the wound inwards towards the tympanic cavity; in which case the improvement is observable only after its absorption.

Fig. 138.

The paralysis of taste, observed by Schwartze after the plicotomy, has not occurred in my cases, as I only incised the fold without allowing the knife to penetrate to the chorda tympani.

Results of the Operation.—The success of the operation mainly depends on the simultaneous changes that take place in the middle ear. The most marked effect of the operation is the diminishing of the subjective noises. The improvement in hearing, which occasionally increases from 4 to 5 metres for conversation, will be the greater the less the ossicular chain is weighted or fixed by pathological products; but where firm anchylosis exists between the ossicula and the walls of the tympanic cavity, the operation will

produce either no improvement in the hearing, or only a very slight one.

As regards the duration of the improvement, we can only judge from such cases as we have had the opportunity of observing for years. In cases where I performed the operation I have noticed that not unfrequently, even after a striking improvement in the hearing and a lessening of the subjective noises had been obtained, a gradual return to the former hearing-distance and a fresh increase of the subjective noises took place in the course of a few months. In other cases the hearing-distance again decreases, while the subjective noises are not so intense as they were before. Only in a very small number of cases have I observed an improvement in the hearing lasting for several years, and a permanent removal or diminution of the subjective noises.

An operation must here be mentioned, which I have repeatedly performed, viz., section of the anterior ligament of the malleus. From experimental examinations, undertaken in order to ascertain the relative proportions of tension in the sound-conducting apparatus, I found that after section of the tendon of the tensor tympani, the handle of the malleus, drawn outwards by aspiration in the external meatus, returns almost to its former position after the aspiration has ceased. But when the anterior ligament of the malleus (anterior portion of the ligament of the axis) is cut, the recoil of the handle inwards almost completely ceases.

Fig. 139.

As this shows that the influence of the anterior ligament of the malleus upon the position of the handle and upon the tension of the membrana tympani is considerable, it is advisable to divide this ligament where the membrane is drawn inwards, the handle of the malleus much inclined inwards, and where, after applying the air-douche several times, a striking improvement takes place, but only of short duration. The instrument here represented (Fig. 139) is a small, narrow, slightly curved knife, cutting at its point and at its concave edge, which is inserted, after dividing the anterior fold of the membrana tympani, to the depth of 2 mm. towards the tympanic cavity, close in front of the short process, when the ligament is divided by an incision made upwards to the Rivinian segment. The effect of the operation in several cases was an immediate decrease of the subjective noises and a permanent marked improvement in hearing for the acoumeter and watch, but in some cases the result was only temporary.

Multiple incision in the membrana tympani, which is recommended when there is excessive tension and thickening, has usually only a transient effect —rarely an improvement remains for a longer time after the operation. On the other hand, in atrophic depressed membrana tympani, I have seen a lasting improvement in hearing after repeated incisions in the flaccid portion; often, however, the beneficial effect after this operation is also transient.

3. *Tenotomy of the Musculus Tensor Tympani and M. Stapedius.*

Division of the tendon of the tensor tympani, proposed by Hyrtl in his *Topographische Anatomie*, 1847, was first performed in the living ear by Weber-Liel in 1868. The operation has for its object the removal of the excessive tension of the membrana tympani and of the ossicula, and of the abnormal increase of pressure in the labyrinth connected therewith, caused by shortening of the tendon. In ascertaining the indications for the operation, in the first place all those diagnostic facts have to be kept in view, from which retraction of the tendon can with safety be inferred.

The most important objective sign of shortening of this tendon is that characteristic condition of great inward curvature of the membrana tympani (Figs. 132 and 133). But quite similar changes in the membrane may be caused by adhesions in the tympanic cavity, especially by shrinking of the folds of mucous membrane and ligaments which extend from the superior external wall of the tympanic cavity to the head of the malleus and the body of the incus. As the head of the malleus is drawn outwards by the shortening of these check-bands, the handle is forced to take the above-described pathognomonic position, even without retraction of the tendon of the tensor tympani.

Of even as little diagnostic value is the striking improvement in the hearing which takes place in cases of hardness of hearing of a high degree after injecting air, and disappears again after a few minutes, or even a few seconds. As absorption of the injected air cannot take place in so short a time, it has been considered probable that the rapid disappearance of the increase in the hearing is caused by the retraction of the tendon reasserting itself immediately after the injection. But this sign also cannot be considered characteristic of shortening of the tendon, as a rapid decrease in the hearing after injecting air may also be produced by the stretching and subsequent rapid retraction of the above ligamentous adhesions, which cause the abnormal inward inclination of the handle of the malleus, without there being any retraction of the tendon of the tensor tympani.

It will therefore be seen that we have as yet no sign from which we can infer with certainty that there is retraction of the tendon of the tensor tympani. But even in cases where it could be distinctly diagnosed, the operation would be really advisable only when this retraction is the sole, or at least the most important, cause of the disturbance of hearing and of the subjective noises. To this, however, our knowledge of the pathological alterations in the adhesive processes of the middle ear is opposed. We have seen that, besides such shortening of the tendon of the tensor tympani, adhesions of the ossicula, a lessened mobility of the stapes, and changes of the fenestra rotunda are to be found, the importance of which in regard to the deafness is not at all or very little altered by division of the tendon. It is therefore asserted with truth, that in the zeal with which some specialists advocated this operation, those changes in the tympanic cavity were entirely overlooked.

Operation.—The instrument for dividing the tendon of the tensor tympani is introduced into the tympanic cavity in front of the

handle of the malleus by some specialists (Weber-Liel), behind it by others (Voltolini, Schwartze, Hartmann, Orne Green). The latter situation is by far the safer, and gives the operation a better chance of success. The revolving sickle of Weber-Liel, as well as the paracentesis needle, curved on the flat (Gruber), do not always produce an incision of the tendon when it is not in the usual position. Choleva operates in front of the malleus with a sickle-shaped knife placed at a right angle to the long axis of the instrument.

The instrument designed by Schwartze consists of a small curved knife, rounded at its point, which is introduced into the tympanic cavity behind the handle of the malleus; the tendon is then divided by a downward incision, a method which is much more difficult than section from below upwards.

Fig. 140.—Hartmann's Tenotome for the Right and the Left Ears (Handle for it, v. p. 269).

The tenotome of Hartmann (Fig. 140) consists of a small knife curved on the flat and on the edge, the point of which reaches about 1 mm. farther outwards than its upper axis. This has proved the most serviceable instrument of all.

To form an accurate estimate of the success of the operation, it is advisable, as was insisted on by Hartmann, first to make an incision into the posterior segment of the membrana tympani about 1 mm. behind the handle of the malleus, and then to ascertain what change occurs in the hearing-distance and in the subjective noises. Then Hartmann's tenotome is introduced through the incision into the tympanic cavity for a distance of about 3 mm., whereby the instrument is placed below the tendon of the tensor tympani between the handle of the malleus and the long crus of the incus. By slightly sinking its handle the sharp point of the tenotome is forced so far towards the upper part of the tympanic cavity, that the tendon is obliquely divided when the instrument is withdrawn.

The division of the tendon is often accompanied by a considerable effusion of blood into the tympanic cavity, which is absorbed after a few weeks (Schwartze). Division of the chorda tympani cannot always be prevented; but the return of the normal sensation of taste takes place in a few weeks.

Results of the Operation.—Immediately after division of the tendon of the tensor tympani, the handle of the malleus is observed to

assume a more vertical position; often, however, it retains the same oblique position which it had previous to the tenotomy, owing to adhesive changes. This confirms the assertion that the already described adhesive changes cause abnormal inclination of the handle of the malleus, independently of traction of the tensor tympani.

According to Pomeroy, Bertolet and Orne Green, a decrease of the subjective noises after the operation is to be considered as the most striking subjective change. The cases described by them cannot, however, be taken as conclusive of the effect of tenotomy upon the tinnitus, because these specialists omitted to observe the effect of a simple incision into the membrane, and plicotomy upon the noises before division of the tendon.

The influence of tenotomy upon the disturbance of hearing is even considerably less. A striking improvement in the hearing has very seldom been observed after tenotomy; in most cases the increase in the hearing-distance is but very trifling, or remains as it was after section of the posterior fold of the membrana tympani. Sometimes, even, a marked change for the worse has been observed after the operation.

To determine the value of tenotomy, the changes which occur several weeks or months after the operation are important. The experience which has been gained in competent quarters is, on the whole, unfavourable to the operation; for with only few exceptions, the improvement in the hearing after tenotomy disappears again completely or to a great extent, and the subjective noises reach their former degree; indeed, not unfrequently a rapid aggravation takes place after the operation, which, judging by the former course of the disease, can be attributed to it alone. Several patients, who consulted me some months after tenotomy had been performed, had become completely deaf on the side operated on, while before the operation the deafness was not great, and had for years made but slow progress. Division of the tensor tympani is, therefore, one of those operations which not only are of but trifling use, but which sometimes also have a deleterious influence upon the function of hearing. That there are cases in which the tenotomy is of use there is no question, but the indications for the operation must be more thoroughly proved by a precise diagnosis than has previously been done.

For the tenotomy of the stapedius in catarrh and adhesive processes without perforation of the membrane, in the present condition of our knowledge, there are no indications proved, and what has previously been said about the operation depends on hypothetical grounds. On the other hand, as we shall consider later, after middle-ear suppuration when the stapedius tendon has been drawn into a cicatricial thickening of the mucous membrane, it is occasionally of value.

4. *Mobilization and Extraction of the Stapes.*

In conclusion, a few remarks may be made about the proposal of Kessel to render the stapes movable, or to extract it in cases of anchylosis. The latter operation Kessel founds upon an experiment on a cropper-pigeon, in which,

after extraction of the columella and the partial discharge of the perilymph from the labyrinth, all response to the action of loud sounds ceased. The sensation of sound returned eight days after the operation with the cessation of the discharge, and dissection showed that the fenestra, which had been opened, was again closed by a newly-formed membrane.

Ricardo Botey reached the same result (*Berliner Congressbericht*, 1890) in his interesting experiments on doves and chickens.

This operation, which has been recommended again in the last few years by Boncheron and Miot, is, according to these authors, indicated in dry middle-ear catarrh where the function of the auditory nerve is intact, and the deafness is of such a degree that conversational speech may still be heard at 1 m., and whispering at $\frac{1}{2}$ m. As contra-indications are severe deafness, which probably indicates a complete anchylosis of the stapes, and diminished perception through the cranial bones. The operation is further contra-indicated in unilateral deafness with lateralization of the tuning-fork from the vertex in the normal or better ear (Miot), and also in cases of Paracusis Willisii, and in those chronic catarrhs which, although not accompanied by subjective noises, have diminished bone-conduction.

Operation according to Boncheron.—The method of operation is as follows: After thoroughly disinfecting and cocainizing the external meatus, an incision is made in the posterior part of the membrana tympani, through which the articulation of the incus and stapes is separated by means of a hook. After this the stapes is mobilized by means of a single or double hook inserted between the crura, in such a manner that by slight traction the stapes is moved upwards and downwards and from before backwards. In cases in which a permanent opening in the membrane is wished, the tendon of the tensor tympani should be cut, and the membrane, with the malleus and incus, removed.

Operation according to Miot.—The preparations for the operation should be made as above, only that in order to make the effect of the cocaine more sure and rapid a slight incision is made on the posterior insertion of the membrane and a 20 per cent. solution of cocaine then applied. By this means in a few minutes the anæsthesia will be so complete that the incision may be extended without the slightest pain. The stapedo-incudal articulation may be exposed in two ways:

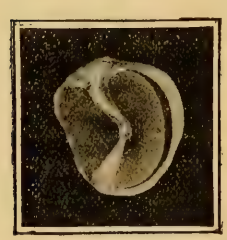

Fig. 141.

1. By making an opening in the posterior superior quadrant of the membrane 2 to 3 mm. in size, through which the stapedo-incudal connection is laid free; or

2. By cutting the membrane with a small bistoury. This is preferred by Miot, as the larger opening allows the movements of the instruments to be better seen.

The incision is made at the posterior periphery, near the circumference of the membrane, in the form of a half-moon (Fig. 141), and the fold of membrane is laid forward with a small spatula in order to see the field for operation. The incision should be quite large, as it must be kept open for

three to four weeks, in order that the remobilization of the stapes may be done without making a new incision in the membrane.

Before one proceeds to the regular mobilization of the stapes the incised membrane and the exposed mucous membrane of the middle ear should be touched first with a sublimate solution (1 in 1,000), and then with a cocaine solution (1 in 15). After a few minutes, a small rounded spatula (palette) is inserted underneath the junction of the stapes and incus and parallel with the crura, and by means of repeated delicate lever movements the stapes is mobilized. If the stapes proves immovable one tries to shove the spatula between the long crus of the stapes and the anterior edge of the niche of the fenestra ovalis, in order to move the stapes from before backwards by means of slight pressure.

The mobilization itself is accompanied by a whistling or ringing sensation in the ear and occasionally by dizziness. Unfavourable accidents during the operation are: severe bleeding from injury to the arteria stapedia, injury to the chorda tympani with paralysis of the sense of taste in the anterior two-thirds of the tongue; further, dislocation of the incudo-stapedial articulation through cutting the stapedius tendon, fracture of the stapes crura, and, lastly, complete dislocation of the stapes with escape of a portion of labyrinthine fluid.

Following the operation the patient occasionally feels slight pain in the ear and in that half of the head, which sometimes may remain for days. In many patients there occurs a sense of weakness, heaviness in the head, dizziness, and somnolence. The inflammatory symptoms after the operation are usually slight, and only rarely has middle-ear suppuration followed.

The perceptible improvement in hearing either occurs at once or only after several days or weeks. If only a slight improvement is accomplished by the operation the remobilization of the stapes is indicated. In several cases Miot only accomplished a good result after repeating the operation three times.

The remobilization of the stapes should only be done at intervals of two or three weeks.

The effect of the operation upon the subjective noises is less than upon the deafness.

If one leaves out of consideration the successful cases of mobilization of the stapes after middle-ear suppuration there are, according to Miot's compilation, twenty good results among fifty-six operations.

The results of mobilization of the stapes up to the present are not sufficient to give this operation a permanent place in the operative treatment of chronic adhesive processes of the middle ear, the number of operated cases being too small and the duration of observation too short. From the pathologico-anatomical standpoint one may conclude that a permanent result is possible only in those cases in which the adhesions are torn by the manipulation. But in those cases where the connective-tissue adhesions are only stretched and pulled, the effect, owing to the shrinking and retraction which soon takes place, is only transient.

The extraction of the anchylosed stapes, as recommended by Kessel and Ricardo Botey, can scarcely ever be successful, as according to my experiments on anatomical preparations when the stapes was anchylosed, even with

careful traction, the crura were broken off. This occurred as well in those cases in which the footplate of the stapes was closely fastened to the fenestra ovalis as in those where the crura of the stapes was adherent to the lower wall of the pelvis ovalis. Completely cutting around and loosening the anchylosed stapes in the fenestra ovalis without damage to the contents of the labyrinth I believe to be impossible, as the surface of the fenestra ovalis is placed at such an angle to the axis of the meatus that a view of the field of operation is scarcely possible. An experience, however, in which pieces of the fractured footplate of the stapes must have penetrated the vestibule, showed how easily a suppurative inflammation may be produced in the labyrinth, which will not only destroy the nerve, but also may reach the meninges through the meatus auditorius internus.

More recently the extraction of the stapes has been done by L. Jack,* in sixteen cases with marked improvement. Of those operated upon, however, there were only five cases of chronic middle-ear catarrh, the other eleven cases being the results of middle-ear suppuration. Jack gives no special indications for the operation and claims that it is easily done, and, according to the experiments on animals by Ricardo Botey, it is entirely without danger.

The extraction of the stapes in chronic dry middle-ear catarrh is carried out as follows. In the posterior superior quadrant of the membrana tympani an incision is made in the form of an inverted V, and the flap being laid back allows the articulation of the incus and stapes to be easily seen. With a deli-

Fig. 142.

cate small knife the tendon of the stapedius is incised close to the head of the stapes, and then the connections of the incus and stapes are cut through with a small triangular knife, placed at right angles to the handle. If the stapes is not cut free the head of it is freed by cutting around it with a pointed knife. The extraction of the stapes is carried out with a small hook (Fig. 142) or by means of a delicately constructed pincette. This manner of operation, by which only the stapes is extracted, according to Jack, gives very much better results than when the membrana tympani with the malleus and incus are removed at the same time. According to his results the crura of the stapes were only broken in one case in the attempt to remove it, leaving the footplate of the stapes in the fenestra ovalis. Only in two cases did severe dizziness occur after the operation, which is always done under narcosis, and this disappeared within four or five days. In order to prevent other complications it is advisable for the patient to remain in bed two or three days with the meatus hermetically stopped. Only in a few cases a slight suppuration occurred after the operation.

The result of the operation in the five cases mentioned, as far as the increase of hearing for speech was concerned, was favourable, the hearing-distance for which was increased from four to ten times. In one of the cases—

* 'Remarkable Improvement in Hearing by removing the Stapes,' Transactions of the American Otolog. Soc., 1892.

a woman, aged thirty, who for six months was so deaf that she could only hear speech through a speaking-tube, suffering also from dizziness and subjective noises—the result was most marked. The hearing-distance on the day following the operation was 7 feet for whispered speech, 10 feet for ordinary speech, and 20 feet for loud speech. Tinnitus and dizziness disappeared after the operation. As difficulty in hearing had only began six months previously, and with a sudden onset, fixation of the stapes in the fenestra ovalis had not occurred. In the other four cases it is evident, from the hearing-distance before the operation, that no anchylotic fixation of the stapes had occurred. As in the sixteen cases the crura of the stapes was broken off in the attempt at removal only once, it is evident that in suppurative middle-ear inflammation (eleven cases) the stapes was loose and that the new formation of connective tissue rarely fixes the stapes in the fenestra ovalis as tightly as in middle-ear catarrh. The fact that increase in hearing remains in the last-named form after the extraction of the stapes, in spite of cicatrization, is only explainable from the fact that the waves of sound, instead of being transmitted through the ossicula, are conducted through the air in the tympanic cavity.

Whether the extraction of the stapes will have a lasting effect, or whether a consecutive suppuration in the labyrinth may not produce dangerous complications, must be shown by more extensive experiments. The published reports of Jack are so favourable that further experiments in this direction should be made.

5. *The Synechotomy of the Crura of the Stapes.*

From the anatomical fact that the fixation of the stapes in the fenestra ovalis in middle-ear catarrh occurs frequently through adherence of the crura with the lower wall of the niche of the pelvis ovalis (Fig. 124, p. 278), I have tried during the last year and a half in a series of cases of chronic dry middle-ear catarrrh, in which the local treatment gave no satisfactory result, to carry out the following operation.* It is only applicable in those cases in which the objective examination gives a marked negative Rinne, lengthened duration of perception for the c^2 tuning-fork through the cranial bones, as well as intact bone-perception for the acoumeter. Besides, the movability of the malleus should be proved by means of Siegle's speculum.

Through the numerous examination of cases which I have made and verified by the autopsy, one finds the cause of deafness to be generally a fixation of the stapes in the fenestra ovalis. If this is produced by calcification or ossification of the borders of the fenestra ovalis or through the growth of the crura of the stapes, furthered by an accompanying change in the fenestra ovalis, it cannot be diagnosed in the living. The operation is therefore always to be considered as an experiment, and an extensive examination for the

* I did the operation of incising the connective-tissue adhesions between the crura of the stapes and the wall of the niche after middle-ear catarrh in 1870, and reported the result at the International Otological Congress in Basle in 1884. (Comp. *Baseler Congressbericht*, 1884.)

differential diagnosis between fixation of the footplate of the stapes and that of the crura should be previously made.

To carry out the operation the posterior superior quadrant of the membrana tympani is opened by means of the galvano-cautery. An opening 3 mm. in diameter should be made, through which, in normal anatomical conditions, the articulation of the incus and stapes should be visible (Fig. 143). Very often the chorda tympani is interfered with, but the paralysis of taste on the affected side is transient. Instead of the galvano-cautery perforation of the membrana tympani, the articulation of the incus and stapes may be laid free by means of a triangular incision in the posterior superior quadrant, with the

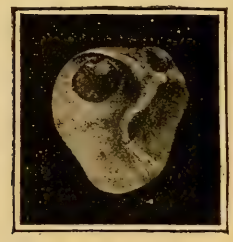

Fig. 143.

Fig. 144.

point of the incision upwards (Fig. 144). In some cases in which the posterior segment of the membrana tympani was so transparent that the articulation of the stapes was visible through it, I did the operation in this manner: Below the visible crura of the stapes I made a horizontal section of the membrana tympani extending to the niche of the fenestra ovalis.

For the synechotomy I use a small knife $\frac{1}{2}$ mm. broad and 1 mm. long, rounded at the end (Fig. 145), which has a projection on its lower surface 1 mm. from the point, corresponding to the convexity of the promontory. This has the advantage of preventing the point of the knife from passing

Fig. 145.

through the orbicular ligament into the vestibule. This precaution is necessary, as the penetration of the instrument into the labyrinth may be followed by permanent dizziness, tinnitus, and complete deafness.

I perform the operation without narcosis, the patient being in a sitting position. As the level of the crura of the stapes are sharply inclined to the horizontal, the head of the patient must be bent well over to the opposite side, in order that the connective tissue between the wall of the niche and the crura of the stapes may be cut through in a horizontal position.

After the opening in the posterior superior quadrant of the membrana tympani has been performed, while the field of operation is well lighted, the region of the fenestra ovalis is painted with a sterilized cocaine solution, by

means of a small pellet of cotton, after which the synechotomy is performed. This is carried out as follows. The instrument being introduced between the crura and the lower wall of the niche, a deep incision is made from right to left until the projection on the instrument prevents its deeper penetration (Fig. 146). If after the operation no marked improvement in hearing occurs one may try with a smaller instrument, without the projection, to loosen the adherence between the anterior crus of the stapes and the wall of the niche, and in a similar manner the posterior crus from the posterior wall of the niche. The latter manipulation is very difficult on account of the projecting tendon of the stapedius, but may be carried out by bending the head strongly to the opposite side.

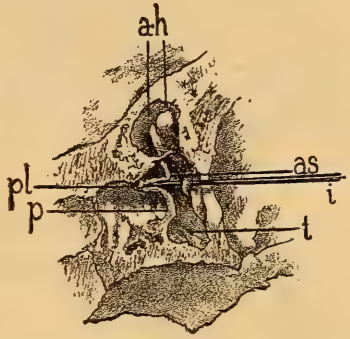

Fig. 146.

a, Attic of the cavum tympani; *t*, Lower portion of the tympanic cavity; *p*, Promontory; *h*, Articulation of the malleus and incus; *pl*, Footplate of the stapes; *i*, the knife penetrating between the stapes and lower wall of the niche.

The synechotomy of the crus of the stapes has been carried out by me in eighteen cases. In four of these cases in which the deafness was of such a high degree that spoken words could be heard only in the immediate neighbourhood of the ear, the stapes proved to be anchylosed, and the result was *nil*. Of the other fourteen cases in only five was there a marked and permanent improvement in hearing, as the hearing-distance increased from 1 to 1½ m. to 4 to 7 mm., and the accompanying subjective noises were decreased. In the other nine cases the improvement in hearing after the operation was of a slight degree and transient.

The cicatrization of the perforation opening followed without reactive inflammation and without adherence with the deeper part of the membrana tympani in all the cases.

As to the value of this operative procedure it is impossible to say anything positive. Further experiments, extending over a longer period of time, must be made in order to consider the indications for its use.

6. *The Excision of the whole Membrana Tympani and the Extraction of the Malleus and Incus.*

Recently it has been tried to produce a persistent opening in the membrana tympani by means of removing the whole membrane with the hammer, thereby producing a permanent improvement in the hearing in chronic dry middle-ear catarrh. While Simrock stated that after complete removal of the membrana tympani with the hammer a membranous cicatrix formed over it, filling the whole opening, which often adheres to the inner wall of the tympanic cavity, Kessel (*Oest. ärztl. Vereinszeitung*, 1879) succeeded, through removing the cartilaginous ring on the posterior circum-

ference of the membrane, in producing a persistent opening, by which means the result of the operation proved permanent (*A. f. O.*, vol. xiii.). According to the experiment of Schwartze (*Chir. Krankh. d. Ohres*) the cicatrization of the defect in the membrana tympani seems to be dependent upon the presence of the cartilage at the limbus. In the cases operated on by him a serous secretion or purulent inflammation of short duration followed the operation, the treatment for which must be carried out for several weeks. The improvement in hearing depends upon whether the hindrance to sound-conduction is in the articulation of the malleus and incus or in the stapes ; in the latter case no improvement in hearing follows. The subjective noises are often decreased, never increased. Lucae (*A. f. O.*, vol. xxii.) did the operation for the removal of the membrana tympani with the hammer fifty-five times in forty-seven

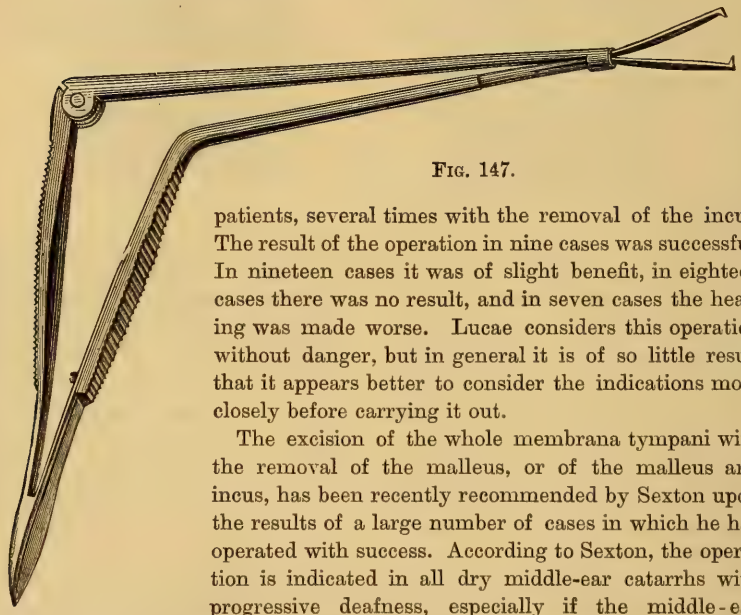

FIG. 147.

patients, several times with the removal of the incus. The result of the operation in nine cases was successful. In nineteen cases it was of slight benefit, in eighteen cases there was no result, and in seven cases the hearing was made worse. Lucae considers this operation without danger, but in general it is of so little result that it appears better to consider the indications more closely before carrying it out.

The excision of the whole membrana tympani with the removal of the malleus, or of the malleus and incus, has been recently recommended by Sexton upon the results of a large number of cases in which he has operated with success. According to Sexton, the operation is indicated in all dry middle-ear catarrhs with progressive deafness, especially if the middle-ear affection is combined with severe subjective noises and dizziness, and the local treatment of the middle ear (catheterization, etc.) has proved useless. The operation will be of so much greater benefit the earlier it is carried out.

The technique of the operation is carried out in chloroform narcosis as follows:

After the field of operation has been well lighted with electric light, with a small knife rounded at the point the whole periphery of the membrana tympani is loosened so that it is only connected above with the malleus, and the tendon of the tensor tympani and the articulation of the stapes and incus are cut through by means of a slightly bent knife. The bleeding, which is generally slight, is stopped by means of tampons of carbolized cotton. The extraction of the ossicula is now carried out by means of a delicate pincette, constructed for the purpose (Fig. 147); the hammer is fastened in the region

of the short process and pulled downwards and eventually extracted with the longer process of the incus. After the removal of the ossicula with the membrana tympani the field of operation is thoroughly disinfected with a solution of sublimate and the ear stopped with carbolized cotton-wool.

The pain following the operation is generally slight and quickly passes away, occasionally a viscid serous secretion takes place into the cavum tympani. Only rarely an intense purulent inflammation follows. Often, however, as Burnett (*Philad. Med. News*, 1891) also reports, subjective noises and dizziness are either removed or diminished.

The improvement in hearing is sometimes only slight. Occasionally this disappears some time after the operation, but Sexton has observed cases where the improvement in hearing has remained over a number of years. Regeneration of the excised membrana tympani often occurs, and occasionally requires the excision of the newly-formed membrane, which it may be even necessary to repeat.

A sufficient judgment as to the therapeutical value of this procedure will only be possible when, from different sides, the results of a large number of cases with a longer duration of observation have been brought forward. In every case the operation should be preceded by opening the membrana tympani by means of the galvano-cautery. If after this a marked improvement in hearing, or a decrease of the annoying noises takes place, one may then try the removal of the whole membrana tympani with the malleus and eventually also the incus. If, on the other hand, after the perforation of the membrana tympani the former condition is unchanged, less result from the operation may be expected.

II. The Muco-purulent Inflammations of the Mucous Membrane of the Middle Ear.

a. Acute Inflammation of the Middle Ear (Otitis Media Acuta).

Syn.: Acuter einfacher Mittelohrcatarrh (v. Tröltsch); Otitis med. acut. simplex; Otite aigue de la caisse (Bonnafont); Iperæmia acuta dell' orecchio medio (de Rossi); Acute catarrhal inflammation of the middle ear (J. Roosa).

Acute inflammation of the lining membrane of the middle ear is characterized by the rapid development of an effusion with more or less violent inflammatory symptoms, and exudation of a muco-purulent or purulent fluid into the middle ear, by a simultaneous secondary inflammation of the membrana tympani, and by its almost typical, definite course of generally short duration. The anatomical changes are characterized at the commencement of the disease by excessive hyperæmia, which is soon followed by sero-purulent exudation partly into the tissue of the diseased mucous membrane, and partly also into the tympanic cavity. In the rare cases in which there is an opportunity for a post-mortem examination, as in cases of typhus fever and puerperal diseases, the mucous

membrane is found much swollen, in consequence of the interstitial serous effusion mixed with exudation cells, and it is sometimes ecchymosed: the fibrillæ of the connective-tissue stratum are forced asunder in the form of a network by the exudation (Wendt), the epithelium is opaque and swollen, and in places raised up and peeled off.

In the cases examined by me, the openings in the network of the pelvis ovalis, niche of the fenestra rotunda and the external attic were filled with plaques of purulent exudate. These changes are always found to a more or less extent, as well on the mucous membrane of the Eustachian tube and the covering of the mastoid cells.

The free effusion into the middle ear consists of a thick, opaque fluid, mucus, and pus cells, and, by the tearing of bloodvessels in the case of very sudden exudation, a great number of red blood corpuscles are sometimes present; but the effusion is frequently composed almost entirely of pus cells with only a slight admixture of mucus. The exudation is not always fluid, but sometimes firm and tough. The muco-purulent secretion which fills the tympanic cavity may be so firm that it can be removed in coherent masses.

In certain rare cases, as shown by the observations of Schwartze, Trautmann, and others, a hæmorrhagic exudate occurs (Otitis Media Hæmorrhagica, Hæmatotympanum).

In most text-books otitis media acuta is treated in connection with primary sero-mucous catarrh as belonging to the same form of disease. If we consider the principal differences between the two we will find in the catarrh that the membrana tympani is very slightly changed, transparent, without injection, or only to a slight degree; while in otitis media acuta there is extensive hyperæmia, inflammation, and exudation on the membrane with complete opacity of it. In the mucous membrane of the tympanic cavity there is only a moderate reaction in the former, while in the latter there is great congestion of the vessels; in the catarrh the exudate is a clear serous fluid, or a transparent mass of mucous, but in otitis med. acuta it is opaque mucous mixed with a large amount of pus cells or a purulent fluid. In catarrh there are no symptoms of reaction, or only very slight, while in otitis acuta there is great reaction with severe symptoms; the former usually runs a slow course, while the inflammatory processes of the latter cease quickly; in catarrh the absorption of the exudate is very slow, but in otitis media it disappears rapidly upon making the tube permeable. These differences, not taking into account those cases which change from one form to the other, give to each form a peculiar clinical character which will influence the choice of treatment in each case.

Etiology.—Acute inflammation of the mucous membrane of the middle ear is most frequently caused by the action of atmospheric influences, exposure to wet, cold baths, acute or chronic catarrh of the

naso-pharynx, scarlatina, measles, variola, typhus, influenza, pneumonia, bronchial catarrh, tuberculosis, puerperal fever, and chronic (sero-mucous) catarrhs of the middle ear. Acute inflammation of the middle ear may be due to the application of Weber's nasal douche (Roosa, Hessler), and all injections into the naso-pharynx accompanied by strong compression, through sniffing or allowing cold fluids to run through the nose (Bezold), through operations on the naso-pharynx, and cauterizing the nasal mucous membrane. This disease occurs much more frequently in children than in adults, and in our climate oftener in spring and autumn than in summer and winter. Generally only one ear is affected, more rarely both, either simultaneously or consecutively one after the other.

A new phase has been given to the etiology and pathological anatomy of otitis media acuta by the recent bacteriological examinations. By the examinations of Zaufal, Moos, Weichselbaum, and others it appears that this ear affection is an infectious disease due to microbic parasites. However, it must be understood that acute middle-ear inflammation does not show, from a bacteriological view, a unanimity in its cause, but that many forms of micro-organisms may produce a similar pathological effect upon the middle ear.

The diplococcus of pneumonia (Fränkel-Weichselbaum) and the streptococcus pyogenes were found most frequently by Zaufal (*Prag. Med. Woch.*, 1890) in middle-ear inflammation. The diplococcus of pneumonia is found mostly in the otitis following pneumonia or due to catching cold, and the streptococcus more often in cases due to traumatism and foreign bodies.

The bacillus pneumonia of Friedländer, first found in middle-ear secretion by Zaufal, appears to occur only sporadically. The other forms of pathogenic staphylococci, which occur in suppuration of all forms, have less importance as regards the middle ear, as when found present in middle-ear inflammation they have generally wandered into the ear secondarily. In only one case have the staphylococci been found as the one pathogenic microbe present where the membrana tympani was not perforated (Weichselbaum). The presence of micro-organisms in the middle-ear secretion is proved by the ordinary methods of bacteriological examinations. As regards etiological value only those should be considered which are found in the middle-ear secretion when the membrane is still intact or at the time of paracentesis. Generally before perforation of the membrane only a single form of microbe will be found in a pure culture. Occasionally several members of the same family will be similarly affected at the same time. After spontaneous perforation of the membrane, especially when the secretion takes a purulent character, pus microbes will be found mixed in the secretion, and the primary microbe will be occasionally put in the background. As regards the microbe in influenza otitis there is as yet no positive statement.

The otitis media shows different clinical characters according to the form of micro-organism causing it. The severest complications (intracranial disease, purulent infection) are, according to Moos, produced by the streptococcus pyogenes and the bacillus pneumonia of Friedländer.

The invasion of micro-organisms into the middle ear occurs most frequently directly from the catarrhally inflamed mucous membrane of the naso-pharynx through the tube (Rohrer, *Morphologie der Bacterien*, etc., 1889), as the micro-organisms found in the middle ear are always present in the naso-pharynx, even in the normal state, and more in the pathological conditions, especially in catarrhal inflammations of the mucous membrane. The micro-organisms may remain dormant in the middle ear for a long time, as in the naso-pharynx, and may then lose their vitality or be forced out through the tube (Zaufal). If, however, the action of some external influence (cold, trauma, etc.) should disturb the nourishment of the mucous membrane and thereby reduce its resistance to bacterial influence, it affords an opportunity for the nourishment and growth of the microbes, and they may then produce an acute exudative inflammation of the middle ear. The indirect entrance by means of the lymphatic spaces occurs in scarlatina and necrosis of the pharyngeal portion of the tube (Moos). Less common means of invasion for the micro-organisms into the middle ear are (*a*) the penetration from the blood stream through the walls of the vessels in endarteritis (Trautmann) and in diphtheria (Moos); (*b*) the penetration through the perforated or intact membrana tympani (in erysipelas, Moos).

Appearance of the Membrana Tympani.—Inspection of the membrana tympani in the slighter forms of inflammation will show great injection, especially on the periphery, in the neighbourhood of the short process and along the handle of the malleus, while the portions of the membrane situated between the handle and the periphery are lustreless and gray, or of a stippled appearance. It is only rarely that a radiating arrangement of the bloodvessels can be distinguished. Very often there occurs at the beginning, especially in influenza otitis, punctate or diffused ecchymoses on the membrana tympani. In the more severe forms the congestion extends over the whole surface of the membrane, which is of a uniform scarlet or livid colour, or, when there is intense injection of its mucous membrane, its colour resembles that of a burnished copper plate. The last-described appearance is observed, however, for a short time only at the commencement of the acute inflammation, because the membrane loses its lustre owing to the rapid progress of the exudation and of the saturation of the epidermis. Through swelling of its epidermic layer the membrane becomes a dirty ash-gray or violet-gray, and the epidermis is not unfrequently cracked, and the grayish-red surface appears divided into irregular patches by numerous dark fissures crossing each other. In this instance the handle of the malleus is almost always invisible, while the short process can sometimes still be distinguished as a yellowish-white protuberance.

The inflammatory infiltration of the membrana tympani is fre-

quently confined to the posterior superior portion, which (Fig. 148) is bulged forward towards the meatus, in the form of a bluish-red, globular swelling, covering the handle of the malleus, resembling a polypus.

There is sometimes a condition observed resembling what is found in myringitis. At the commencement one or more blisters are formed, which burst after a short time, and pour out a serous or reddish fluid into the meatus. Interlamellar abscesses (Eysell) are rare in this form. In some rare cases, in which the membrana tympani is only slightly affected by the inflammatory process, the grayish-yellow exudation, just as in hypopyon, may be seen deposited in the lower part of the tympanic cavity.

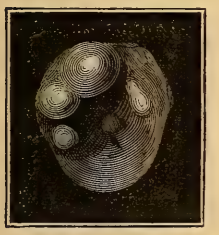

FIG. 148.—BLUISH-RED, GLOBULAR SWELLINGS ON THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI—ECCHYMOSES.

Appearance in a man, 47 years of age, 15 hours after the commencement of the inflammation; height of inflammation and subsidence of the swelling on the sixth day. Cured after 14 days.

FIG. 149.—GLOBULAR SAC ON THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI; AT THE BASE OF THE SWELLING A YELLOWISH-GREEN EXUDATION, DEFINED BY A CURVED LINE WITH ITS CONCAVITY UPWARDS.

From a woman 30 years of age, who was taken into the Aural Clinic 2 days after the commencement of a painful inflammation. After the inflammation had passed away the posterior portion of the membrane remained thinned.

FIG. 150.—BAG-SHAPED, BULGED-OUT SWELLING COVERING THE HANDLE OF THE MALLEUS, COMMENCING AT THE POSTERIOR SUPERIOR PORTION OF THE MEMBRANE. THE INFERIOR PORTION OF THE BAG CONTAINED A YELLOWISH-GREEN OPAQUE EXUDATION AFTER INFLATION.

Appearance in a young man on the third day after the commencement of inflammation. Cure in 3 weeks.

Occasionally there occurs a sero-hæmorrhagic secretion on the external surface of the membrana tympani without destruction of its continuity; or there may be perforation, accompanied by a serous discharge, closing in a short time, after which it shows the clinical course of a simple acute middle-ear inflammation.

Exudation-sacs on the membrana tympani, communicating with the tympanic cavity, are among those rarer occurrences in acute inflammations of the middle ear which have hitherto been little noticed. They are situated on the posterior superior portion of the membrana tympani, and are loose, globular, or bag-shaped (Figs. 149 and 150) and are of a greenish or yellowish-gray

colour. That these sacs are in connection with the tympanic cavity is proved by the fact that after injecting air into the tympanic cavity, in the inferior portion of the sac may be seen the exudation, which is demarcated by a sharp line from the upper portion filled with air.

I have seen these saccular swellings on the membrana tympani communicating with the tympanic cavity more frequently in adults than in children. They often develop very rapidly on a previously normal membrana tympani, more frequently, however, in individuals in whom, owing to a middle-ear catarrh, there has been atrophy of the superior posterior portions of the membrane. In the latter case there usually remains after the acute inflammation an atrophic thinning and depression of the posterior portion of the membrane which lies in contact with the articulation of the incus and stapes.

Symptoms.—The disease commences as a rule with a stinging, jerking pain in the ear, extending to the vertex, neck and teeth, which is sometimes preceded by a feeling of numbness and fulness in the ear or by violent headache. In adults the pain rarely reaches such a degree of severity as in children, in whom so-called otalgia is very frequently nothing less than the accompanying symptom of an acute inflammation of the middle ear. The pain is seldom continuous, but it intermits, so that in the evening and during the night it is most severe, while during the day it diminishes. This intermission is specially complete in children, so that after violent paroxysms of pain, during which the little patients writhe with agony, pauses of several hours will follow, in which the children's cheerfulness and brightness completely return. The pain is increased by coughing, clearing of the throat, and swallowing. Pressure upon the external region of the ear and upon the mastoid process rarely causes pain in adults in the simple inflammation, but more frequently in influenza otitis; on the other hand, the region corresponding with the Eustachian tube below the auricle is usually tender on pressure. Children frequently show great tenderness of the whole external region of the ear.

Acute inflammation of the middle ear is frequently, but not constantly, accompanied by subjective sensations of hearing, such as ringing, hissing, whistling, and whizzing. The noises frequently assume a pulsating character. This feeling of pulsation sometimes corresponds, as I was the first to prove on the intact membrana tympani, with a visible pulsating motion of the membrane, on which either single spots of light, or a considerable portion of the bulging membrane (Roosa) show motions synchronous with the contractions of the heart. The subjective noises are caused either by coincident hyperæmia and effusion in the labyrinth, or by the clogging of the fenestræ of the labyrinth by the effused exudation. Their speedy disappearance in the course of the inflammation is to be considered

as a favourable sign, and their uninterrupted continuance after the inflammation has ended as an unfavourable one.

A frequent symptom in acute inflammation of the middle ear is the feeling of heaviness and numbness of the head, and the resonance of the patient's own voice, which frequently lasts until the inflammation has completely subsided. Urbantschitsch observed an alteration in the sensation of taste on that half of the tongue corresponding with the diseased ear. Attacks of giddiness, with a staggering gait (Böke), are on the whole rare.

Acute purulent inflammation of the middle ear is sometimes accompanied by fever at its commencement and during its progress. High fever is met with most frequently in children in whom delirium, and even convulsions, may also be observed.

On the border between the secretive middle-ear catarrh and otitis media acuta occurs that not very rare subacute inflammation which runs its course with slight reaction, without fever, and scarcely marked general symptoms, with exception of a sero-mucous exudate. The very opaque, yellowish-gray membrana tympani with the depressed umbo and great prominence of the membrane lying between the malleus and the periphery shows a radiary injection which lasts generally a long time. This form, characterized by its protracted course, occurs in scrofulous, cachectic, and tuberculous individuals, but also in healthy persons, especially in the young with long-continued secretive middle-ear catarrh.

Disturbances of Hearing.—In the first stage of the inflammation, in which the pain reaches its climax, the decrease in hearing is usually slight. Next, in the stage of exudation, in which the pain gradually disappears, and a decrease of the hyperæmia in the membrana tympani is observed, the hardness of hearing increases to a considerable extent, partly in consequence of the accumulation of exudation in the tympanic cavity, partly by swelling and infiltration of the mucous membrane of the tympanic cavity and tube.

The power of perception through the cranial bones is, as a rule, normal. The watch and the acoumeter are inaudible from the temples in very exceptional cases only, and they are cases of genuine inflammations when the affection of the middle ear is complicated with great hyperæmia and serous saturation of the labyrinth, also in secondary syphilis, and in consumptive and decrepit individuals. The tuning-fork, with few exceptions, is perceived in unilateral inflammations better from the vertex in the affected ear.

The auscultation-sounds (p. 104) vary according to the character of the secretion and to the degree of the swelling in the Eustachian tube. The more liquid the exudation, the more distinctly will the rattling noises be perceived; they may be quite wanting in tough or viscid exudation; the greater the swelling in the Eustachian tube, the rougher, sharper, and more irregular will be the noise produced by the entering air.

Course, Duration, and Result.—The course and the duration of acute inflammation of the middle ear depend on the intensity of the process, on its cause, and on the general condition of the patient. In simple inflammations occurring in a healthy constitution the duration of the congestion, combined with pain, varies from a few hours to eight days and more. In most cases the pain has reached its climax on the third or fourth day, when with the appearance of the exudation it disappears, and a considerable increase of the hardness of hearing results, which is subject to more or less remarkable fluctuations in the subsequent course, until the function is again normal.

With the decrease of pain as a rule the disappearance of the diffuse hyperæmia in the membrana tympani also commences, the

FIG. 151.—RADIATE VASCULAR DEVELOPMENT ON THE POSTERIOR HALF OF THE MEMBRANA TYMPANI.
Appearance in a man on the eighth day after the commencement of the inflammation; colour of the membrane yellowish-gray; hardness of hearing of a high degree; immediately after the application of my method considerable improvement in the hearing. Disappearance of the opacity of the membrane, and return to the normal state in the fourth week.

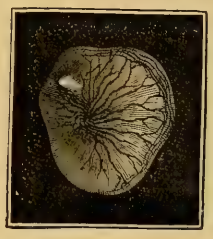

FIG. 152.—RADIATE VASCULAR INJECTION OF THE MEMBRANA TYMPANI.
Appearance in a woman 33 years of age, on the ninth day after the commencement of the inflammation; membrane normal at the end of the fourth week.

swelling of the membrane subsides, it receives a yellowish or leaden-gray appearance, the short process of the malleus is more plainly visible, while the handle is covered by the persistent hyperæmia of its vascular bundle. Simultaneously with the disappearance of the general congestion, a number of sharply defined vascular branches appear on the membrana tympani (Figs. 151 and 152), and extend as slightly tortuous twigs from the periphery towards the centre and towards the handle of the malleus.

According, however, as the absorption of the exudation takes place, these bloodvessels quickly decrease, and disappear altogether, the lustre of membrane returns again, the handle becomes visible, the gray opaque membrane again becomes clear, and as a rule

regains its former normal appearance, with the restitution of the hearing-power.

Occasionally it will be found, especially after frequent relapses of the inflammation, that partial and diffuse opacities, calcareous spots, and circumscribed atrophies of the membrane, with partial retractions, remain.

The duration of acute inflammation of the middle ear until a completely normal state is regained varies in the normal course from a few days to three weeks and more. In general the course of the disease is more favourable in summer than in the autumn or winter. In healthy individuals under favourable external conditions, it shows a rapid course; but in weak anæmic persons, or when occurring with the acute exanthemata, influenza, typhus, in scrofular and tubercular individuals, or in recurrent otitis media, the course is generally protracted. Very often painful exacerbations occur following pernicious external influences or improper diet (alcoholic), and occasionally without a discoverable cause. Relapses of that kind may recur several times, and in this inflammatory form I wish to attach special importance to the disappearance and to the recurrence of the pain, because only with the decrease of the pain may a decided lessening of the inflammation be expected, while the return of the pain almost always points to an increase of the inflammatory process. After influenza otitis there often remains a persistent tinnitus, which either disappears after several months, or is the forerunner of a middle-ear catarrh with progressive deafness.

The results of acute middle-ear inflammation are: 1. Healing. 2. Transition of the inflammation into the chronic catarrh, which either heals or goes on to adhesive changes in the sound-conducting apparatus. 3. Acute middle-ear suppuration with perforation of the membrana tympani. 4. Fatal results from meningitis or sinus phlebitis, or, according to my observations, through a general infection extending from the middle ear (otitis media infectiosa) without disease of the venous sinus.

After inflammation has been cured, a disposition to relapses will generally remain for a considerable time. In children especially, the inflammation frequently recurs for several years almost regularly in spring and in autumn, during a severe cold in the head or a sore throat. Such relapses may again end in cure; frequently, however, a growth of connective tissue in the mucous membrane of the middle ear is caused by the recurring inflammation, which impairs the power of vibration of the ossicula, and hearing-disturbances of a slight degree will then remain.

Diagnosis.—There is no difficulty in diagnosis if one considers the

duration of the disease, the characteristic condition of the membrana tympani, and the general symptoms. The mistaking of it for myringitis acuta is possible only in the first stages when the disturbance of hearing is slight (p. 236). Also in the diminution of the disease it is not always possible to say whether the inflammation will subside without perforation of the membrana tympani, or whether an otitis media suppurativa with perforation of the membrane will supervene.

Prognosis.—This is favourable in the genuine inflammation occurring in healthy individuals under good conditions of life. It is unfavourable in infectious diseases, in individual dyscrasias, and after frequent recurrence; farther in persons who cannot avoid detrimental external influences during the disease.

Treatment.—The treatment of acute inflammation of the middle ear in the beginning of the disease, and as long as the congestion and the active symptoms last, is palliative. The main duty of the practitioner at this time consists in the removal or alleviation of pain.

In inflammations of a slighter degree, which are accompanied by moderate, not continuous pain, narcotic embrocations in the region of the ear, repeated every two or three hours, generally suffice to remove the pain; if it is paroxysmal it will be removed in the quickest manner by dipping a plug of cotton-wool into five or six drops of a warm narcotic oil,* and inserting it into the external orifice of the ear. To rapidly alleviate attacks of pain I also apply opium ointment or a mixture of olive oil and chloroform in equal proportions, of which twenty to thirty drops are dropped upon a piece of wadding of the size of the palm of the hand, covering the region of the ear. Embrocations of oil and chloroform must be avoided, because they frequently produce a violent acute eczema in the external region of the ear.

The ear-baths recommended by v. Tröltsch consisting of filling the meatus with warm water often quickly eases the pain. Their use must not be continued longer than 10 to 15 minutes, for when long continued the fluid in the meatus macerates the epithelium of the membrana tympani, and favours the unwished-for perforation of the membrane. The longer use of the ear-baths is only indicated where there is great pain and the membrane is bulged outward, with a yellowish colour at the most prominent portion, but paracentesis is impossible on account of the resistance of the patient. Instead of the simple ear-baths, aqua opii with aqua destill., or luke-warm

* Ol. olivarum 10·0, acet. morph. 0·2; or ol. hyoscyam. press. 10·0, extr. laud. aquos. 0·8.

instillations of a 5 to 10 per cent. solution of cocaine may be used. If the latter proves of no effect owing to the thickness of the epidermis of the membrane, the instillation of 5 to 6 drops of a 5 per cent. solution of cocaine into the nostril may be tried with the head bent to that side. By this means some of the fluid reaches the pharyngeal orifice of the Eustachian tube, and by capillary attraction is carried along the canal. Cold applications to the region of the ear occasionally alleviate the pain, but in most cases they are not well borne. Warm poultices are not to be recommended in spite of their soothing effect, as they increase the hyperæmia in the meatus, and favour the perforation of the membrane.

For the same reason, the introduction of hot vapours into the external meatus by means of paper funnels, which is often practised by laymen, must be entirely discarded, because by the immediate action of the hot vapours upon the membrana tympani the exudation may burst outwards still more easily than when fomentations are applied.

Moist, warm fomentations to the region of the ear, however, prove very effective; a light piece of linen of the size of a dinner-plate, folded several times and dipped into tepid water or in a tepid solution of tinct. opii (2 parts to 200 parts of water), if applied to the region of the ear, covered with oiled silk, tied up with a dry handkerchief, and changed three or four times during the day, is often of excellent service. Besides that, in my practice I frequently order in cases in which the pain obstinately continues, and that not only in acute otitis media, but also in all inflammatory affections of the ear accompanied by pain, the whole head to be wrapped up in a linen cloth, dipped in warm water, to be changed after 2 or 3 hours, and this often has an exceedingly good effect.

The internal use of antipyrine (in half-gramme doses), and, when there is accompanying fever, phenacetin (0·25 grm. doses) at intervals of 2 hours, will alleviate the pain.

If sleep is disturbed by the severe pain the administration of a narcotic is indicated. One may give 2 to 3 doses of acet. morphia (0·005 to 0·015 grm.) for the night, or in case this does not agree, hydrate of chloral (1·50 to 2·50 grm. in solution), sulphanol (1 to 2 grm.—it should only be used a short time), or paraldehyde (2 grm. per dose). Only rarely in this form of inflammation is it necessary to resort to the subcutaneous injections of morphia (on the neck or arm of the diseased side). Should there be an idiosyncrasy against morphia, subcutaneous injections of antipyrine (1 grm.) may be used with benefit (Turnbull).

When at the beginning of the otitis media acuta, with extensive inflammatory symptoms on the membrana tympani, there is incessant severe pain in spite of the external and internal use of narcotics, local bleeding is indicated. By this means the inflammatory processes are neither altered nor shortened, although in many cases the severe pain is decreased or completely alleviated. For this purpose the leech is placed in front of the trages in the course of the venous vessels, into which the veins of the tympanic cavity empty. The number of leeches varies from 1 in children to 2 to 4 for a healthy adult. In anæmia local bleeding is contra-indicated.

If the application of the leeches is left to the relations of the patient, the exact spot in front of the tragus must be marked at which they are to be applied. To prevent the entrance of the leech or the flow of blood into the meatus it should be closed with cotton. Where a rapid depletion of the vessels, or an exact control of the quantity of blood is wished, the Heurteloupe apparatus, or the rarefacteur of Delstanche, provided with a glass tube, is to be preferred to the leech.

Besides these local medications, the patient should not leave the house, especially in cold and stormy weather, until all reactive symptoms have disappeared, in order to avoid a relapse. If fever is present it is better for the patient to remain in bed, as through the transpiration in the even warmth of the bed, not only are the general symptoms improved, but also the pain will more quickly disappear. To favour the transpiration a cup of tea, or an infusion of linden blossoms may be drunk, the effect of which may be increased by the addition of a teaspoonful of spirit. mindereri (℞ Infus. flor. tiliæ 10·0, aqua dest. s. 150·0, spirit. mindereri 5·0, Syr. cort. aurant. 40·0; M. Sig. A tablespoonful every hour). In the stage of reaction the diet should be regulated, and the use of alcoholic drinks, as well as smoking, must be forbidden. If the otitis media is combined with catarrhal angina an astringent gargle (althæa decoct., with alum and the addition of tinct. opii) should be used. Warm general baths often increase the pain.

The paracentesis of the membrana tympani (p. 268) in acute middle-ear inflammation is only indicated when with exudate in the middle ear the severe pain, with or without fever, remains in spite of the local treatment, and circumscribed livid-red protuberances (Fig. 148) are seen on the membrana tympani, or it shows on its most bulging portions a yellowish-green colour. Through the paracentesis the pain is often quickly relieved, but occasionally it returns in spite of the discharge of the pus. In excessive livid swelling of the cutis, scarification of the most prominent portion of the membrane (Blake) is often sufficient to relieve the severe pain. Such multiple incisions of the inflamed cutis are usually followed by a slight sero-hæmorrhagic discharge, and on the next day by a moderate collection of pus on the mem-

brane, after the rapid disappearance of which desquamation of dry epidermis plates occurs. After the paracentesis a muco-purulent or purulent discharge occurs, which, in case of thick exudate, will not appear until one to two days after the operation, and may continue several weeks or months, until the close of the opening. In scrofulous, tuberculous and debilitated individuals, I have seen the most protracted chronic middle-ear suppuration with its results developed after a paracentesis.

In the slighter forms of acute middle-ear inflammation the paracentesis of the membrana tympani is contra-indicated, as I have repeatedly observed in bilateral affections, after the paracentesis of the membrane, in one ear a long-continued muco-purulent discharge; while in the other ear the healing and completed restoration of hearing occurred much earlier after the use of the air-douche according to my method.

The disturbance of hearing which accompanies middle-ear inflammation is most quickly relieved by the air-douche according to my method. At the beginning of the disease, during the painful reactive stage, it should not be used, as the sudden increase of pressure in the tympanic cavity will increase the inflammatory irritation and pain. With the cessation of the pain and rapid decrease of the hearing the permeability of the tube and removal, *i.e.*, the resorption of the exudates, should be brought about by use of the air-douche. To disinfect the air which is forced in, it should be aspirated through some Brun's cotton placed over the opening.

In the greater majority of the cases by this means alone the exudate will be removed, and complete healing brought about (comp. p. 83). At the beginning only slight pressure with the balloon (p. 116) or with the mouth should be used, and instead of the act of swallowing a sharp inspiration, or the pronunciation of a word, may be used. At a later stage a greater pressure during the act of swallowing should be used, as by this means the healing will be the more quickly brought about in children as well as in adults.

The statement lately made by some that with an intact membrana tympani infectious particles of mucus may be forced from the naso-pharynx into the middle ear by means of the air-douche according to my method, and thereby produce an otitis media acuta, is contrary to every established fact. It is remarkable that during the use of my method for twenty years, while so many observations as to its effects have been made, from no side has there been any intimation that it could be considered the cause of acute middle-ear inflammation. Only recently, since the presence of micro-organisms in the secretions of acute otitis media have been proved, has the hypothesis been advanced that by my method infectious mucus was forced into the middle ear.

As the pressure of air in my method is not a direct current of air into the middle ear as occurs in catheterization, but is a condensation of the column of air in the tympanic cavity, secretion lying in the naso-pharynx or ostium

pharyng.-tubæ will only be pressed so far into the tube, as the cavity of the middle ear is increased by the giving of the membrana tympani. In regard to the introduction of infectious particles from the middle ear by this method, the consideration of the physical conditions is sufficient to refute all statements.

If this were the case the tympanic cavity would be filled with secretion in a short time every time the nose was forcibly blown.

The fact is that no clinical observation has shown an otitis media acuta to occur after the air-douche according to my method. It is to be regretted that after this favourable result some otologists should hinder any practising physician from using this method, and by this means prevent many patients from receiving the necessary treatment which they require.

With regard to the observation of Bürkner, that by means of the air-douche with the catheter infection of the tympanic cavity is more easily prevented than through the inflation of air according to my method, it is to be remarked that, on the contrary, by the catheter secretion from the naso-pharynx may be forced into the tympanic cavity very much more easily. It is certain that by introducing the catheter into the Eustachian tube secretion from the naso-pharynx is introduced even as far as the isthmus of the tube, and through the air-douche following, the secretion will be easily forced into the tympanic cavity.

In all cases, therefore, in which air can be forced into the tympanic cavity with sufficient strength, by means of my method the use of the catheter is contra-indicated, for through the immediate contact of the instrument with the inflamed mucous membrane the swelling is increased, and by the transmission of the mechanical irritation from the tube the inflammatory process in the middle ear is increased. Only in rare cases, when the swelling of the tube is very great, is it necessary to use the catheter.

The marked improvement in hearing which often takes place immediately after the first inflation of air, is partially gone before the next day, if the secretion continues undiminished. Only when the improvement in hearing after the air-douche remains constant for 24 hours, or, as it occasionally occurs, increases, can one judge that the exudation is diminishing. From this time the air-douche should not be used daily, but only every second, later every third, day; and at the last it is only necessary once a week, until the hearing is normal.

Injection of medicated solutions by means of the catheter through the tube into the tympanic cavity is, according to my experience in this form of inflammation, directly detrimental. They lengthen not only the course of the inflammation, but very often cause an increase of the pain and exudation.

In viscid exudate which is not easily absorbed, the subcutaneous injection of pilocarpine muriat. (4 to 5 drops of a 2 per cent. solution) for several days has proved beneficial. The massage of the

region anterior to the ear, and of the mastoid process after the reactive stage is over, is recommended to increase absorption. The rubbing, which should be from above downward, gentle at first, and later stronger, may be repeated twice a day for four or five months.

The treatment of the naso-pharyngeal affections accompanying middle-ear inflammation will be given in a special portion.

b. Acute Purulent Inflammation of the Middle Ear.

Syn.: Otitis media acuta suppurativa seu perforativa; Antro-tympanitis of early authors; Periostitis auris med. (Rau); Acuter eitriger Ohrcatarrh (v. Tröltsch); Acute suppuration of the middle ear (Roosa); Otite media piogenica a forma acuta (De Rossi).

Acute purulent inflammation of the middle ear is characterized by hyperæmia of the mucous membrane, generally setting in with violent febrile symptoms, swelling and cell infiltration into the mucous membrane of the middle ear, which leads to a rapid exudation of pus and to perforation of the membrana tympani, which is at the same time inflamed. The anatomical changes are the same as those with which we became acquainted in the description of acute inflammation of the middle ear, with this difference, that in the suppurative form the inflammatory changes of the mucous membrane are much more intense, the exudation is more copious and contains greater numbers of pus cells, and perforation of the membrana tympani takes place.

The pathological changes in this form of inflammation almost always extend over the whole mucous membrane of the middle ear. Even in those cases where during life no symptoms of irritation were present on the mastoid process, I always found post-mortem purulent exudate in the antrum and mastoid cells. The labyrinth remains generally intact, or the free anastomosis between the vessels of the middle and inner ears leads to great hyperæmia in the labyrinth, and serous effusion, but seldom to purulent inflammation.

Etiology and Occurrence.—Acute purulent inflammation of the middle ear is produced by the same causes as acute middle-ear inflammation without perforation of the membrana tympani. Also here the most frequent causes are external influences, after colds, acute or chronic naso-pharyngeal catarrh, scarlatina, measles, smallpox, typhus, tuberculosis, diphtheritis, pneumonia, influenza, whooping-cough, syphilis, diabetes, erysipelas, and the puerperal state. Traumatic acute suppuration in the middle ear is sometimes caused by paracentesis, or by other operations on the membrana tympani, also by contusions of the cranium or of the ear by a blow or a fall,

by forcible attempts at extraction of foreign bodies from the ear, and by scalding and cauterization of the ear. That acute suppuration of the middle ear may be caused by Weber's nasal douche, by injections of cold water into the external meatus, by cold river or sea baths (Knapp, Morpurgo), through insufflation of fluid through the nose (alum water, Knapp), has already been mentioned.

Acute purulent inflammation of the middle ear occurs more frequently in children than in adults, and is observed oftener in spring and in autumn than in summer and during the winter. In spring it sometimes bears an epidemic character. Climate does not seem to have any considerable influence upon the frequency of this inflammatory form; Knapp (*Z. f. O.*, vol. viii.) has calculated, from careful examinations of statistics, that in American as well as in European medical institutions the percentage of aural patients (6 to 7 per cent.) is pretty equal. In the idiopathic and in the traumatic forms the inflammation affects most commonly one ear; in scarlatinal and typhoid forms more frequently both.

The excessively frequent occurrence of purulent inflammations of the middle ear in childhood, especially in the course of acute exanthemata, in congenital syphilis, in severe naso-pharyngeal affections, bronchial catarrhs and pneumonia, is an indisputable fact.

In infants Dr. Emil Pins considers the cause of frequent purulent middle-ear inflammation to be due to the entrance of water into the external meatus during the daily bath. The existence of purulent middle-ear inflammation in the newly-born is favoured by the absorption of the cushion of the mucous membrane, accompanied by hyperæmia and swelling of the mucous membrane in the middle ear.

Acute Inflammation of the External Attic of the Tympanic Cavity.—Clinical observation during the last ten years leaves no doubt that circumscript acute inflammation in the tympanic cavity occurs, while Blake and Sexton consider the seat of the inflammation to be in the upper portion of the tympanic cavity known as the attic, I had previously stated (*Lehrb.*, 2 Aufl., s. 265) that the cases known as inflammation of the attic were due to an inflammation of a limited external portion of it (Logette des osselets, Gellés). The exudation is partly in Prussak's space, partly in the space between the malleus and incus, and the external wall of the tympanic cavity. The acute inflammation of the external attic may be produced by the same pernicious influences as otitis media acuta; several times I have observed it in influenza. Sexton considers naso-pharyngeal catarrh and the acute exanthemata as etiological factors. The subjective symptoms are similar to those of the diffuse otitis media acuta. Examination shows intense redness at the upper pole of the

membrana tympani, and on the wall of the meatus bordering it the membrana shrapnelli projects from the upper pole of the membrane in the form of a bulla (Fig. 154), which quickly subsides upon the pus breaking through or after the perforation of the sac, and emptying of the secretion (Fig. 155). Abscess formation rarely occurs in Prussak's space, with the formation of a yellowish-green projection, the size of a hemp seed, on the membrana shrapnelli, which after paracentesis discharges a small amount of purulent secretion (Fig. 156). The results of this form of inflammation are: 1. Healing without disturbance of hearing. 2. Diminishing of the hearing through the formation of adhesions between the bodies of the hammer and incus and the bordering wall of the niche. 3. Transition into the chronic suppuration of the external attic, the results of which will be discussed in the following section.

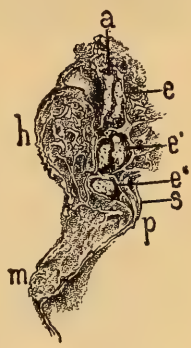

FIG. 153.—FRONTAL SECTION THROUGH THE HAMMER AND EXTERNAL ATTIC OF THE LEFT EAR, IN A WOMAN AGED 91, WHO HAD PURULENT MIDDLE-EAR INFLAMMATION DURING THE LAST DAYS OF HER LIFE.
h, hammer; *a*, external attic; *p*, process brevis mallei; *m*, manubrium mallei; *s*, membrana shrapnelli; *e e'*, plaques of exudate in the external attic; *e''*, exudate into Prussak's space. (After a preparation in my collection.)

Condition of the Membrana Tympani in Acute Purulent Inflammation of the Middle Ear.—Previous to perforation the membrane is either uniformly scarlet-red or yellowish-red, occasionally livid and ecchymosed; in influenza-otitis, covered with great extravasation or bullæ filled with blood (Schwabach, Wendt, Politzer), the posterior portion bulged outwards, partly covered with epidermis, after the casting off of which the moist surface of the prominent membrana tympani may be mistaken for roundish polypi. The handle of the malleus is hidden by the swollen cutis, while the short process is distinct from the reddened surface, looking like a whitish-yellow pustule. The small, scattered reflections of light show, often even before perforation of the membrane, a distinct pulsation, as was first observed by me.

In rare cases, for a very short time at the commencement of the disease, small, circumscribed protuberances in the form of blisters or of roundish, yellowish-green, interlamellar abscesses are found. At the apex of these protuberances a yellowish-green flat or pointed place is sometimes observed, where, later on, the pus breaks through towards the outside; often, however, it is not possible to ascertain the spot where the perforation of the membrane will take place,

although the examination is made immediately before the perforation.

In the cartilaginous portion of the meatus painful swellings occur

FIG. 154.—A REDDISH-YELLOW SAC OF EXUDATION HANGING FROM THE UPPER POLE OF THE MEMBRANA TYMPANI AND COVERING THE HAMMER.

Condition on the eighth day of the disease, in a man aged 18 years, with the symptoms of an acute otitis media. Otorrhœa began on the ninth day. Ac. = 18 cm.; whispering = 4 m.

FIG. 155. — CONDITION OF THE MEMBRANA TYMPANI IN THE SAME INDIVIDUAL ON THE SEVENTEENTH DAY OF THE DISEASE.

Otorrhœa stopped after the sixth day. The sac of exudation has mostly disappeared. The handle of the malleus is partially visible. Ac. = $1\frac{1}{2}$ m., whispering = nearly normal.

FIG. 156.—FORMATION OF AN ABSCESS IN PRUSSAK'S SPACE, WITH BULGING OF THE MEMBRANA SHRAPNELLI, IN A MAN AGED 49, ON THE FIFTH DAY OF THE DISEASE.

Paracentesis; after a short time healing.

in very severe middle-ear inflammation, especially in children, which extends to the external region of the ear, and the lymphatic glands behind the ear. The osseous meatus is nearly always injected,

FIG. 157.—ABSCESS OF THE SIZE OF A MILLET-SEED IN THE CENTRE OF THE MEMBRANA TYMPANI, 6 HOURS AFTER THE COMMENCEMENT OF THE INFLAMMATION.

Perforation of the membrane the next day at the same place. Hearing-distance before the perforation: Acoumeter = $\frac{1}{3}$ m., whispered speech = 2 m. From a diabetic patient 30 years of age.

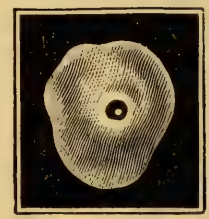

FIG. 158. — PERFORATION OF THE SIZE OF A POPPY-SEED BEHIND THE UMBO IN THE FOURTH WEEK OF THE DISEASE.

The perforation occurred the third day after the commencement of the inflammation. Hearing-distance: Acoumeter = 2 cm.; speech = $\frac{1}{3}$ m. From a man 65 years of age.

swollen, and the transition into the membrana tympani is indistinct.

The condition of the parts is materially changed after perforation.

The osseous meatus is swollen, and covered with shreds of exfoliated epidermis. The membrana tympani, coated with pus, appears, after syringing out the secretion, partially covered with macerated epidermis, in places excoriated, greatly congested and livid, and its curvature effaced or irregular and uneven, and the angle between the membrane and meatus is indistinct. The handle of the malleus is almost never visible, and the short process only occasionally. The perforation appears in cases of moderate discharge as a sharply-defined, black orifice (Fig. 158), of the size of a poppy-seed or a puncture with a needle, in which from time to time a small pulsating air-bubble is visible. The point of perforation is, however, generally not discovered at all, or is only indicated by a small depression filled with secretion, and with a pulsating reflection of light.

FIG. 159.—CONDITION OF THE MEMBRANE IN THE SAME PATIENT AT THE END OF THE SIXTH WEEK. THE OTORRHŒA HAD CEASED FOR A FORTNIGHT. THE PERFORATION IS CLOSED BY A YELLOWISH-GRAY, SOMEWHAT DEPRESSED CICATRIX, TO WHICH SEVERAL SMALL VASCULAR TWIGS EXTEND FROM THE PERIPHERY OF THE MEMBRANE.
Hearing-distance: Acoumeter = 10 cm.; speech = 3 m.

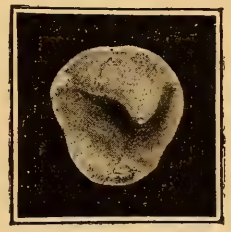

FIG. 160. — A NIPPLE-SHAPED BULGING OF THE POSTERIOR PORTION OF THE MEMBRANA TYMPANI, ON THE SUMMIT OF WHICH IS THE PERFORATION.
In a woman aged 28 years. Condition in the fourth week of the disease, abscess of the mastoid process. Opening of the mastoid process five days after the operation, the point on the membrana tympani disappeared. Healing.

The most frequent position for perforation is between the handle of the hammer and the tendinous ring, more often in front than behind the hammer (Wilde, Bing). Often the space of perforation is not visible until the edges of the perforation are forced apart by means of the air-douche in the middle ear. Sometimes the perforation opening is situated at the point of a nipple-shaped projection, at the posterior portion of the membrana tympani, out of which a drop of pus exudes, upon using Valsalva's method, without forcing the air through the perforation (Fig. 160). This form of perforation, which is especially frequent in influenza-otitis (Löwenberg), is practically important, as, according to my observation, it is often combined with a painful inflammation of the mastoid process,

and the middle-ear suppuration shows an extremely protracted course.

The Character of the Secretion.—The secretion is not always purulent at the beginning, but is like serum, containing blood or a clear yellow viscid fluid, which assumes a purulent character after several days. While a purulent secretion is diffused uniformly in warm water used for syringing the ear, a muco-purulent discharge forms larger or smaller oblong flakes and threads, and extensive lumps with irregular outlines. Sometimes the secretion is so trifling that no discharge from the ear takes place, while in other cases the discharge is so rapid and abundant that the whole field of view is flooded again with secretion soon after syringing. The character of the discharge often changes during the course of the disease; thus a muco-purulent secretion is followed by a discharge of liquid pus, free from mucus, and *vice versâ*. This fact deserves notice, because, according to my observations, the inflammations of the middle ear which are accompanied by profuse pustular secretion mixed with mucus are always more obstinate than those forms in which the secretion is pure pus. Hæmorrhagic secretion occurs in cachectic individuals, leukæmia, traumatic inflammation (Truckenbrod), Bright's disease, and in endocarditis following diphtheria of the throat (Trautmann).

Symptoms.—Purulent inflammation of the middle ear generally commences with stinging, aching, piercing or throbbing pains in the ear, which extend to the vertex, occiput, teeth and shoulder, and commonly reach a higher degree than in acute inflammation. Children especially suffer intense pain, quite out of proportion to the pain felt by adults. It is rare for a sensation of fulness and numbness in the ear or violent headache to precede the pain by a few days. The pain is seldom completely remittent. It is generally increased towards the evening and in the night, while towards morning it commonly so decreases that the patient sleeps uninterruptedly for several hours. Coughing, sneezing, clearing the throat, swallowing, bodily exertion or mental excitement, as a rule increase the pain in a high degree.

Symptoms of irritation of the conjunctiva of the same side, œdema of the eyelids, and photophobia (Wilde, Rau) rarely occur, and only in very severe inflammations before the perforation of the membrane. The inflammation is rarely complicated by facial nerve paralysis, or accompanying affections of the Gasserian ganglion producing trigeminal neuralgia (Moos, Politzer).

Subjective noises are a frequent but not a constant symptom. They arise partly from increase of the labyrinthine pressure, partly from simultaneous hyperæmia and serous exudation in the labyrinth; in many forms, especially in typhus, probably from an infiltration of small cells into the ending of the auditory nerves. The noises ar

described as rustling, roaring, hissing, knocking, and hammering. They often have a pulsating character, and this sensation frequently corresponds with the pulsating motion visible on the membrana tympani. Autophonia often occurs in this form (Sexton).

Acute purulent inflammation of the middle ear is often associated with violent fever and fulness of the head, more rarely with giddiness. The head symptoms may reach such a high degree, especially in young children, that the disease, which not unfrequently is accompanied by fever, vomiting, unconsciousness, and convulsions, bears for the first few days, before the perforation of the membrana tympani, the characters of a meningeal affection or of an acute exanthem, commencing with brain symptoms. This is explainable if one considers the intimate connection between the vessels of the tympanic cavity and the cranial cavity through the ununited sutures in the child (Wagenhäuser). If in such cases the membrana tympani is not inspected, it will only be by the occurrence of a purulent discharge from the ear, and the disappearance of the violent phenomena, that the cerebral symptoms will be discovered to have been caused by ear disease.

The practitioner must always keep this fact in view, that in the treatment of children in the case of acute, feverish illness, accompanied by brain symptoms, one must never omit to make a minute examination of the ear, to ascertain by the condition of the membrana tympani whether the phenomena originates in the ear or not, so as to prevent by timely treatment the development of dangerous complications.

An important clinical symptom of otitis media acuta in children, when they are not capable of localizing the pain, is the fact that such children often lean the head to the affected side, and place their hands upon the diseased ear.

The symptoms in adults are generally less violent. Often the most violent inflammations of the middle ear pass away without the smallest disturbance of the general health. Sometimes, however, especially in otitis med. septica, the increase in the temperature, acceleration of the pulse, and fulness in the head, reach a very high degree; but unconsciousness and delirium rarely occur, and that only in very nervous people, with brain congestion and meningeal irritation.

Disturbances of Hearing.—At the beginning of the inflammation the deafness is often trifling; as, however, exudation rapidly takes place, severe deafness will also rapidly occur. After perforation and escape of the secretion have taken place, the hearing-distance generally increases, but will continually vary during the further

course according to the quantity of secretion and the increase and decrease of the swelling.

The power of perception for watch or acoumeter through the cranial bones is as a rule completely preserved, only exceptionally disappearing before the perforation, to return again after it has taken place. But in those serious scarlatinal or diphtheritic forms which occur most frequently in childhood, where the expansion of the auditory nerve is disorganized by a simultaneous exudation or through immigration of micro-organisms (Moos), or where the labyrinthine capsule is opened by acute caries, or lastly in syphilitic inflammation, the power of perception will completely disappear. The vibrations of the tuning-fork in Weber's test are almost always predominantly perceived by the affected ear, only in exceptional cases by the normal or less affected one. Rinne's test gives no positive result.

Course and Issue.—The course of acute purulent inflammation of the middle ear depends principally on its cause, on the intensity of the process, on the constitution of the individual, and on the external circumstances of the patient. The time which elapses from the beginning of the inflammation to the perforation of the membrana tympani is very variable, and depends on the variable resistance of the inflamed membrane to the pressure of the collected secretion. While sometimes even a few hours after the commencement of the process the membrane is found perforated, the perforation as a rule takes place only on the third or fourth day, and in protracted inflammations sometimes only after two to three weeks.

After the perforation has taken place, which is felt sometimes as if a bladder were bursting, and after the rapid and abundant discharge, the pain ceases either very soon or gradually. Sometimes, however, it continues after the perforation of the membrane with uninterrupted violence, and it is probable that in such cases not only are the superficial layers of the mucous membrane affected by the inflammation, but also the deeper layer of periosteum.

In regard to prognosis, the sensation of pain is of importance in so far as when it diminishes, a decrease of the inflammation may be inferred, while continuous and recurrent pain points to a continuation or exacerbation of the inflammatory process.

After the purulent effusion takes place, the feverishness and head symptoms usually disappear, and the subjective noises either cease altogether, or are weakened; but in very nervous, cachectic and tubercular individuals, in influenza, the scarlatina-diphtheritic form, and in syphilis, the noises in the ear frequently continue with the same intensity.

The changes in the disease, subsequent to perforation, are most remarkable in young children. The violent pain suddenly ceases, the pyrexia declines, and a lengthened sleep takes place. If the inflammation was associated with symptoms of cerebral irritation, with convulsions and unconsciousness, these symptoms also often abruptly disappear.

During the first few days succeeding perforation, the secretion is generally very abundant. The abatement of the inflammatory process is indicated in the normal course, generally in the second week of the disease, by a gradual lessening of the effusion, and by the decrease or discontinuance of the visible pulsation on the membrana tympani. In proportion as the secretion lessens, an increase in the hearing-distance will be observable, a result of the subsidence of the swelling of the mucous membrane of the middle ear. Finally the secretion ceases altogether, and the orifice of the perforation is closed by newly-formed tissue. The cicatrization takes place either gradually, or so quickly that the orifice is closed during one night, while on the previous day there was still a copious discharge, and the air rushed out with a loud rattling noise.

The duration of the suppuration until the perforation is closed varies in the simple forms from ten to twenty days. There are, however, cases in which the secretion ceases after two or three days, while in others the suppuration continues for several weeks or months.

After the closure of the perforation, the membrana tympani is found to be grayish-red and lustreless, only the short process being sharply defined. The site of the former perforation is indicated by a yellowish-gray, somewhat depressed cicatrix, to which there sometimes extend from the periphery of the membrane several small vascular twigs (Fig. 159); frequently, however, the cicatrix cannot be distinguished. In the subsequent course of the disease, the diffuse congestion disappears, the malleus becomes distinctly visible, and the lustre and transparency of the membrane return so completely, that frequently no trace of a past inflammatory process is observable on the membrane. Often, however, the inflammation leaves permanent traces on the membrane in the form of opacities, calcareous deposits, cicatrices and partial atrophies, but these changes are not always accompanied by disturbance of hearing.

The normal hearing function returns in the usual course of the disease within a few weeks after the perforation closes, in summer more rapidly than in winter.

An irregular protracted course often occurs in middle-ear suppuration during the course of scarlatina, typhus, and severe

puerperal affections, influenza, tuberculosis; also in cachectic people, farther in complication with otitis externa, with inflammation and abscess formation in the mastoid process. Lastly, in cases in which the perforation opening is on the point of a nipple-shaped projection of the membrana tympani (Fig. 166), or where the acute formation of granulations upon the membrana tympani or on the mucous membrane of the tympanic cavity occurs.

The signs which indicate such an irregular course are frequently recurring attacks of pain, repeated increase of the already diminishing effusion, and its long duration. The symptoms of exacerbation are most marked in those cases in which inflammation of the mastoid process has developed during the suppuration, or in which closure of the margins of the perforation takes place, while the suppuration still continues. The consequences of such temporary closures recurring in the course of the disease are a number of very violent reactive symptoms, produced by the retention of pus in the middle ear, which only subside when by the pressure of the accumulated secretion the adherent margins of the wound are forced asunder, and the obstacle to the discharge is thus removed.

The results of acute purulent inflammation of the middle ear are:

1. Cure, with complete restoration of the hearing-power. This takes place, as a rule, within three or four weeks, not unfrequently, however, only after several months.

2. Transition of the purulent inflammation after cicatrization of the perforation into serous-mucous catarrh.

3. Permanent hearing-disturbances after the perforation has closed, due to connective-tissue adhesion in the tympanic cavity. This issue is most frequently observed in scrofulous, sickly people with naso-pharyngeal catarrh or ozæna.

4. Permanent hearing-disturbances in consequence of extensive losses of substance in the membrana tympani, with or without simultaneous destructive changes in the ossicula (caries, exfoliation), or in consequence of consecutive copious purulent or mycotic exudations in the labyrinth, which often completely destroy the function of the auditory nerve. These changes are most frequent after scarlatino-diphtheritic suppuration of the middle ear.

5. Inflammation of the cells of the mastoid process. They develop especially often in influenza-otitis, and generally go on to the formation of a circumscribed abscess connected with the antrum and tympanic cavity. These complications appear more often in children, and the perforation of the abscess takes place externally with exfoliation of a necrotic portion of bone.

6. Acute purulent inflammation of the middle ear causes, in some

rare cases, death, after the perforation of the membrane; sometimes, however, without perforation. This is due either to pyæmia, or to meningitis, abscess of the brain (as I observed in a case of influenza), thrombosis of the cranial sinuses, or erosion of the carotid (Toynbee), in consequence of acute caries of the walls of the tympanic cavity (Roosa), or of the mastoid process, and occasionally with no discoverable anatomical lesion (Marian).

7. Transition of the acute purulent inflammation of the middle ear into chronic suppuration of the middle ear, which will be discussed in the next division.

Diagnosis.—The differential diagnosis between otitis media acuta and otitis media perforativa is nearly impossible at the first stage of the process, as the inflammation may subside without perforation, even when the symptoms are intense, while, on the other hand, with slight objective and subjective symptoms, the perforation of the membrana tympani follows. Only when there are marked formations of projections on the membrana tympani, in which the yellowish-green pus shows through, or where the projection is pointed like a pustule, can one say the perforation will follow.

After the perforation has taken place, the diagnosis of acute suppuration of the middle ear is determined: (1) By ocular inspection, as the perforation becomes visible either at once after removal of the secretion, or after air has been forced through from the tympanic cavity. (2) By auscultation, by which the hissing and rattling of the air pressed into the middle ear can be heard escaping through the perforation. This method is of value especially in those cases in which the orifice, situated in the anterior portion of the membrana tympani, is hidden by the great curvature of the anterior inferior wall of the meatus, or in which the perforation cannot be seen, on account of the discharge being too profuse. It is worthy of notice that sometimes the air easily penetrates with little pressure, while it ceases when the pressure is increased. This happens in those rare cases of perforation in which a canal exists, extending obliquely through the layers of the membrane. (3) Through the condensation of air in the external meatus, by which means the air will be forced through the Eustachian tube into the pharynx, and may be heard, by means of a diagnostic tube placed in the nostril. This method is especially indicated if the inspection and auscultation of the external meatus gives no result.

The diagnosis is difficult in children, as the perforation is only rarely visible, on account of the great swelling and narrowing of the external meatus, and the rapid discharge of the secretion.

To determine the diagnosis in such cases, whether it is acute purulent inflammation of the middle ear, or whether it is otitis externa, the character of the secretion has first to be taken into consideration. If it contains large, tough, mucous flakes, we are justified in diagnosing an acute purulent inflammation of the middle ear, because the secretion in primary otitis externa contains no mucus. The absence of mucus from the discharge does not by any means exclude the existence of an acute suppuration in the middle ear, where in children the diagnosis of the perforation cannot be made from the condition of the membrana tympani or the character of the secretion. The auscultation during my method will give a differential diagnosis between otitis externa and otitis media purulenta.

Prognosis.—The prognosis of acute purulent inflammations of the middle ear is considered favourable if the disease is simple, or has been produced by a naso-pharyngeal catarrh spreading to the middle ear, if the affection occurs in a healthy individual, and the patient lives in favourable external circumstances. Symptoms of favourable import during the course of the disease are: Perforation during the first days of the affection, speedy decrease in the pain, early lessening of the secretion and of the pulsation in the membrana tympani, and lastly, steady increase of the hearing-distance during the discharge. The prognosis is, however, unfavourable in scrofulous, tubercular, and syphilitic individuals, in diabetic persons, and in cachectic people reduced by some general disease and in troubles of the sexual organs; also in cases of suppuration of the middle ear which have developed in the course of scarlatina and scarlatina-diphtheria, but less unfavourable in inflammations during measles and typhus.

Symptoms of unfavourable import during the course of the disease are: The continuance and frequent recurrence of pain, permanent profuse discharge after the disease has lasted several weeks, or bleeding from the ear; uninterrupted subjective noises, the rapid absorption of the tissue of the membrana tympani with speedy enlargement of the perforation, the occurrence of granulations on the membrana tympani and in the tympanic cavity, the expulsion of one or more of the ossicula, the appearance of swelling in the osseous meatus, painful varying swelling on the mastoid process, great infiltration of the glands on the side of the head, with suppuration of the glandular tissue, and functional disturbances within the range of the facial nerve. Occasionally complete healing occurs in spite of complication with pyæmia, meningeal symptoms, pareses, or paralysis.

Treatment.—The treatment of acute suppuration of the middle ear at the beginning of the disease, and before the perforation of the membrana tympani, is similar to that of acute otitis media. Therefore, to avoid repetition, we must refer the reader to the division on that disease (p. 325).

If the membrana tympani appears strongly bulging and of a greenish colour before perforation occurs, and if the affection is accompanied by severe pain, fever, brain symptoms—in short, with the symptoms of a collection of pus in the tympanic cavity, the paracentesis of the membrane should be at once performed. By this means not only will the violent pain be quickly alleviated, but the danger of the inflammation spreading to the cranial cavity will also be removed. But the operation is also advisable in cases in which the symptoms of the formation of abscess in the mastoid process are present; further if severe sleep-disturbing pain continually exists, which cannot be alleviated by local or internal medication, even if the membrana tympani is not noticeably bulged forwards. Paracentesis is indicated by early closure of the perforation opening, if it is accompanied by severe pain and the symptoms of retention of pus (Paracentesis, p. 268).

When performing the operation, special care must be taken that the membrana tympani is completely divided, and that the orifice of the incision is widened sufficiently. The secretion in the tympanic cavity escapes either immediately after the incision, or, if the inflammation has produced a viscid exudation, only after one or two days. To accelerate the liquefaction of the masses in the tympanic cavity, it is advisable to fill the meatus several times daily with warm water (v. Tröltsch's ear-baths), or to instil a warm 2 per cent. pilocarpin solution into the external meatus. Where after the paracentesis or spontaneous perforation of the membrana tympani the pain still continues, the instillation of from 10 to 15 drops of cocaine muriat. (3 to 10 per cent.), or a 2 per cent. cocaine and atropin solution (Rohrer), has a very beneficial effect; yet there are cases in which these methods are unsuccessful, and the injection of warm water through the middle ear by the catheter is successful. In stagnation of the secretion owing to too small an opening, it must be widened by means of a paracentesis needle.

During the first days after the perforation, the treatment is confined to the removal of the secretion by washing the meatus with warm water, sterilized or previously boiled water (26° to 28° C.), and only in the farther course of the disease is the use of weak boric acid solution or resorcin solution (2 to 3 per cent.) resorted to. A weak stream of water suffices to remove the secretion deposited

in the meatus. For this purpose small vulcanite syringes, holding about 80 to 100 grms. of fluid, with a short rounded nozzle, are most suitable, or the soft indiarubber balloon. The number of injections during twenty-four hours depends on the amount of the discharge: when it is profuse, the ear must be cleaned out every hour; while in the case of a moderate secretion, two or three injections per day are sufficient. After the removal of the secretion the external meatus should be stopped with carbolized cotton-wool.

To remove the secretion thoroughly from the middle ear, it must be driven into the external meatus by a current of air through the Eustachian tube into the tympanum. For this purpose the air-douche, according to my method, is specially suitable, used with increasing pressure of air. The therapeutical effect is, as Knapp observes, greater than by catheterization, which should be only used in exceptional cases, with marked resistance in the tube, as the repeated use of the catheter increases the swelling and secretion in the middle ear.

Through this simple method of treatment it is often possible to arrest the suppuration and to bring about a complete cure without any other applications. In cases, however, in which after injecting air for several days no decrease of the secretion is observed, it is well to apply local treatment for its more rapid arrest.

The most efficient medicine in acute purulent middle-ear inflammation is crystallized boric acid, as recommended by Bezold. The advantage of this over the astringents formally used consists in the shortening of the term of treatment (Bezold, E. de Rossi, Morpurgo). The boric acid seldom produces the return of inflammatory symptoms, which is observed by the use of astringents.

After having washed and dried the meatus, a small quantity of the powder is blown into the meatus by means of a suitable powder-blower, or a goose quill attached to a rubber tube, so far that the membrana tympani is covered with a thick layer of it. Then the meatus is closed with Brun's cotton-wool, and the powder is left in the ear until the following day. If it is then saturated, the ear is washed out, and boracic acid is again blown in. This treatment is continued until the powder remains perfectly dry after having been twenty-four hours in the ear, when it is left two or three days longer in the meatus, which is then washed out. If the powder in the ear remains dry for several days, it may with probability be inferred that the suppuration has ceased. Where, after the repeated use of boracic acid, no diminishing of the secretion was noticeable, I have seen a rapid result if a tampon of cotton saturated with iodoform was introduced as far as the membrana tympani, and after the application of

this, for several days returning to the treatment with boric acid. Astringents (zinci sulph., sacch. saturin 0·2 in 20, 10 to 15 drops twice a day, instilled into the ear, and left for a quarter of an hour) are only used when boric acid is without result.

A method of treatment which is excellent in its results in the obstinate acute suppurations of the middle ear, consists of injections of sterilized warm water through the catheter into the middle ear (p. 110). This method, recommended by Saissy and Millingen, is of great value in those cases in which the pain continues uninterruptedly after the perforation of the membrana tympani, and the suppuration cannot be arrested by the local treatment described; also in those obstinate forms, in which the perforation is situated on a nipple-like elevation of the membrana tympani; and lastly with inflammatory symptoms on the mastoid process. It often has a surprisingly rapid effect, as immediately after the injection of the fluid the pain generally ceases, and the suppuration decreases after a few days. In the scarlatino-diphtheritic and middle-ear inflammation occurring with measles, one may use in place of the sterilized water a 2 to 3 per cent. solution of boric acid or resorcin.

The painful inflammations of the mastoid process, which appear in the course of acute purulent inflammation of the middle-ear, deserve special attention, and the treatment will be considered in the section on 'The Diseases of the Mastoid Process.'

If the perforation closes after the discharge has ceased, all further local treatment through the external meatus must be avoided, and Politzerization alone must be continued subsequently in treating the still existing deafness. At the beginning this is applied daily, later only once every other day, and if the deafness steadily decreases, only once or twice weekly, until the hearing-test indicates a complete return to the normal state. Many functional disturbances, which cannot be removed by treatment, I have sometimes seen disappear after residence for several weeks in a mountainous district.

With regard to prophylaxis, it must still be remarked, that after acute suppurations of the middle ear have ceased, on account of the tendency to relapse, the meatus must be protected by cotton-wool in cold and windy weather, and vapour-baths or head-douches, as well as diving while in the bath, must be forbidden. With regard to the naso-pharynx affections accompanying middle-ear suppuration, they will be treated in a special section. The peculiarities of the middle-ear suppuration accompanying the infectious disease will also be specially treated.

c. Chronic Purulent Inflammation of the Middle Ear.

Syn.: Otitis media suppurativa s. perforativa chron.; Otitis interna of the older authors; Chronischer eitriger Ohrcatarrh (v. Tröltsch); Chronic suppuration of the middle ear (Roosa); Chronic purulent inflammation of the middle ear (Burnett); Otite profonde de l'oreille moyenne (Bonnafont); Otite media piogenica a forma chronica (De Rossi).

Chronic purulent inflammation of the middle-ear is one of the most important diseases of the ear, not only on account of the frequency of its occurrence, and the deterioration of hearing caused by it, but also on account of the general disturbances of nutrition which not unfrequently are developed in the course of such protracted suppurations, and principally on account of those dangerous complications which are sometimes produced by the suppuration spreading to the cranial cavity and to the venous sinuses.

In no form of inflammation of the middle ear is the hearing apparatus subjected to such extensive changes as in chronic suppuration. The suppurative process involves not only the whole middle ear, but almost always the membrana tympani, and often enough also the external meatus, the labyrinth, and the osseous walls of the middle ear.

Pathologico-Anatomical Changes.—The epithelium of the mucous membrane of the middle ear often loses its ciliated character in chronic middle-ear suppuration, but I have seen cases in which, in spite of suppuration continued for years, the hypertrophic mucous membrane was covered with several layers of cylindrical ciliated epithelium.

The epithelium of the tympanic cavity takes an epidermal character, especially through invasion of the epidermis of the external meatus into the tympanic cavity (*vide* Cholesteatoma). In microscopical sections the mucous membrane of the middle ear appears entirely free from epithelium in certain places, while at other places the excessively developed epithelium is in several layers.

The most important change in the mucous membrane in chronic suppuration of the middle ear consists of increase in bulk, caused by excessive infiltration with round cells and enlargement and new formation of vessels. While in this process the periosteal layer of the mucous membrane is either wholly or partially preserved, the sub-epithelial layer is so replaced by round cells, that a suppurating granulation-surface, traversed by many vessels, takes its place (Fig. 161). The mucous membrane appears red or yellowish-red, of several times its original thickness, smooth or glandular, with microscopically small, irregular, or fungoid excrescences (Fig. 163, *z z'*), and frequently so proliferated that the air-spaces of the middle ear, the depressions in the walls of the tympanic cavity, or a great part of the space of the tympanic cavity, are filled by the hypertrophied mucous membrane. Besides this I found in

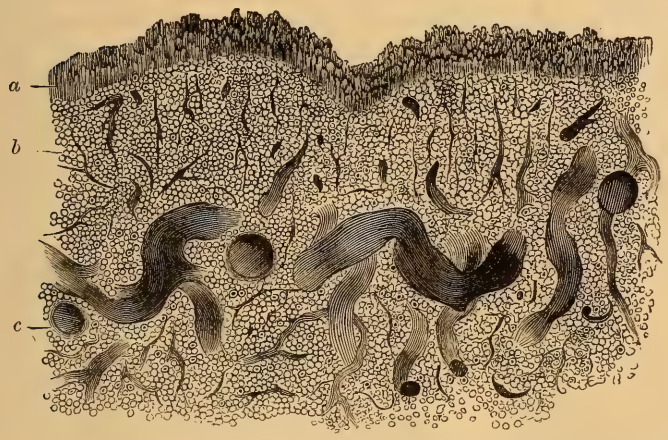

FIG. 161.—SECTION OF THE TUMEFIED MUCOUS MEMBRANE OF THE POSTERIOR WALL OF THE TYMPANIC CAVITY IN THE RIGHT EAR OF A GIRL, 19 YEARS OF AGE, WHO SUFFERED SINCE CHILDHOOD FROM PURULENT INFLAMMATION OF THE MIDDLE EAR ON BOTH SIDES, AND WHO DIED OF ENCEPHALO-MENINGITIS BY EXTENSION OF THE SUPPURATION FROM THE LEFT EAR TO THE CRANIAL CAVITY.

a, Proliferation of the epithelial layer; *b*, Sub-epithelial layer of mucous membrane interspersed with lymphoid corpuscles and few ramifications of bloodvessels; *c*, Deeper layer of the mucous membrane interspersed with highly dilated bloodvessels (Hartnack, Obj. 7).

FIG. 162.—DILATED NETWORK OF LYMPHATIC VESSELS IN THE DEEPER LAYERS OF THE COVERING OF THE PROMONTORY IN A PHTHISICAL PERSON, 27 YEARS OLD, WHO HAD OTORRHŒA SINCE CHILDHOOD. (RIGHT EAR.) (Hartnack, Obj. 7.)

chronic middle-ear suppuration in the deeper layers of the mucous membrane enlarged lymphatic vessels, as varicose projections with blind endings, the stems of which form an anastomosing net (Fig. 162).

Besides these one sees occasionally the cystoid spaces, as described by me, in the mucous membrane, which appear as lymphatic spaces and are disconnected with those lying in the deeper layers (Fig. 163), while the cysts which occur in the superficial granular layers are often lined with epithelium (Fig. 163, *c c''*) and are formed by the growth of papillary excrescences which close the depressions between them.

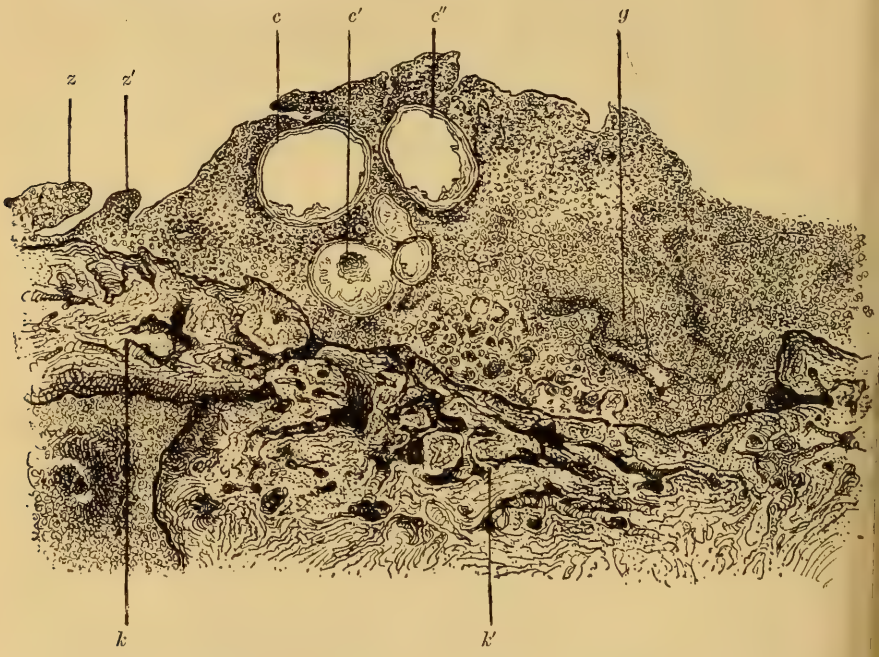

FIG. 163.—HYPERTROPHY OF THE MUCOUS MEMBRANE IN OTITIS MED. SUPPURATIVA CHRON.

k k', Cross section of the osseous wall of the promontory, with excessively dilated vessels and osseous spaces; *g*, the much thickened and infiltrated mucous membrane of the promontory—vessel-formation below; *z z'*, villous-shaped growth on the surface of the mucous membrane; *c c' c''*, cystoid spaces in the excessively developed mucous membrane; *c'*, lamellar lump of epithelium in the cyst. From a man aged 19, who had middle-ear suppuration on the right side since infancy and died of acute osteo-myelitis.

The results of suppuration of the middle ear in chronic middle-ear suppuration may be classified as follows: (1) the hypertrophy of the mucous membrane may subside by fatty metamorphosis and degeneration of the round cells, but the tissue of the mucous membrane, even in the slighter forms, will scarcely again assume its normal character, as it does after acute inflammation of short duration; (2) by partial hyperplasia of the infiltrated mucous membrane circumscribed elevations are developed in the form of granulations or of predunculated new formations, which are called polypi of

the tympanic cavity; (3) by transformation of the round into spindle-shaped cells there occurs a formation of a firm connective tissue, similar to cicatricial tissue, in the form of diffuse tendinous calcareous thickenings of the mucous membrane, or of bridges and thick scars, which leads to abnormal adhesion between the membrana tympani, the ossicula, and the walls of the tympanic cavity. These new-formations of connective tissue may be permanent, or in the subsequent course of the disease shrivelling and sclerosis, calcification, or ossification of the new-formation, more rarely atrophy of the mucous membrane, may result. (4) The purulent process leads to destruction of the tissue, to ulceration, and wasting of the mucous membrane, which is destroyed down to the bone, in which case the ulceration may spread to it.

The changes in the middle ear enumerated here may be developed one after the other at different periods of the suppurative process, or they may exist simultaneously. In this way, in the same ear, besides granulations on the mucous membrane, a firm organized new-formation of connective tissue, and in other places again an ulcerative defect, extending to the bone, may be found.

FIG. 164.—VILLOUS GROWTHS ON A PERFORATED MEMBRANA TYMPANI. FROM A TUBERCULAR SUBJECT, WHO DIED IN THE GENERAL INFIRMARY OF SECONDARY MENINGITIS BASILARIS, AND WHO SUFFERED FOR MANY YEARS FROM A PROFUSE SUPPURATION OF THE MIDDLE EAR.

a, Proliferating dermic layer, with villous projections; *b*, Substantia propria; *c*, Layer of mucous membrane.

The membrana tympani almost always suffers a loss of its continuity in chronic suppuration of the middle ear. Cases in which the suppurative process runs its course without perforation of the membrane are so exceedingly rare, that the assumption that perforation of the membrana tympani is not characteristic of chronic suppuration of the middle ear appears entirely unfounded. While in acute purulent inflammation of the middle ear, as a rule, only a disturbance in the continuity of the membrana tympani takes place, we have here to deal with loss of substance, produced by absorption of the tissue of the membrane at the margins of the perforation.

The destruction attacks, as a rule, the portions of the membrane situated midway between the periphery and the handle of the malleus. Even in the case of very extensive losses of substance, in the majority of instances, the peripheral portion of the membrane is still found preserved in the form of a detached sickle-shaped ledge. This is not always formed by the tendinous ring, as is generally believed, but, as I have convinced myself from several post-mortem examinations, by the dense peripheral circular fibrous bundles of the membrana tympani.

Sometimes the membrane is uniformly thickened and tumefied, sometimes the layer of mucous membrane alone shows an excess of growth towards the tympanic cavity, or a general papillary or polypoid hypertrophy of the cuticular layer may occur (Fig. 164), while the substantia propria remains

either unchanged or is partially or wholly supplanted by exudate, calcareous masses, or the excessively developed connective-tissue elements in the neighbouring layers.

After suppuration has ceased, either the margins of the perforation are covered with epithelium, and a permanent aperture in the membrana tympani remains, or the orifice is closed by a delicate and thin cicatricial tissue, in which the elastic fibres of the substantia propria are wanting. The remains of the membrana tympani are either thickened, calcified, ossified, or atrophied, and its inner surface sometimes adheres more or less to the inner wall of the tympanic cavity.

The mucous membrane of the Eustachian tube is swollen and proliferated, the acinous glands of the mucous membrane are enlarged, the acini and their ducts are dilated, the epithelium is lacking or is in layers. Formation of granulations or polypi on the mucous membrane of the tube is rare. After the course of chronic suppuration there remains in most cases a moderate narrowing of the Eustachian tube, rarely there occurs a marked dilatation of the tube through atrophy of the cartilage and bony walls.

The pathological changes in the mastoid process will be described in a special portion.

Indeed, on microscopic examination it will very frequently be found, even in those cases in which the bone is apparently normal, after the mucous membrane has been detached, that those prolongations of connective tissue and osseous spaces are infiltrated with round cells, and that the vascular spaces are dilated; in a word, that the phenomena of inflammation of the bone are more or less strongly pronounced. This leads either to condensation of the osseous tissue, to hyperostosis and the formation of osteophytes, or to caries and necrosis of the temporal bone and of the ossicula, with all the consequences with which we shall become acquainted in the course of this division.

To get a better view of the changes which take place in the course of chronic suppuration of the middle ear, it seems to me advisable to describe first the purulent processes which are not aggravated by deep complications, and to discuss separately the polypoid formations as well as the carious diseases and their results.

Etiology and Occurrence.—The transition from acute suppuration of the middle ear to the chronic form is caused partly by general and constitutional diseases (scrofula, tuberculosis, syphilis, anæmia, and marasmus); partly by local changes in the ear and in the neighbouring naso-pharynx. There is nothing positive known as regards the effect of micro-organisms upon the chronicity of middle-ear suppuration. The acute middle-ear suppurations occurring in scarlatina and diphtheria and more rarely in typhus have a tendency to be transformed into the chronic form. That chronic suppuration of the middle ear does not always originate from an inflammation, which at its commencement presents the characters of acute otitis purulenta, but that it may also be developed without acute phenomena, espe-

cially in certain cachexias, also without reactionary symptoms, has already been pointed out.

Of the local causes which lead to the chronicity of the suppuration the most important are: (1) The granulations and polypoid growths on the mucous membrane of the tympanic cavity and on the membrana tympani, which are developed in the acute stage; (2) retention and caseation of the purulent exudation in the different recesses of the tympanic cavity, of the petrous bone, and of the mastoid process; (3) periostitis and caries, which are developed during the acute stage in the mastoid process, or in some other portion of the temporal bone; (4) chronic inflammation of the external meatus and of the membrana tympani, if the process has spread from thence to the middle ear; (5) chronic blenorrhœa of the mucous membrane of the naso-pharynx, and ozæna.

Chronic purulent inflammation of the middle ear occurs most frequently in childhood. That a large proportion of the purulent processes which are observed in adults date from childhood has been placed beyond doubt. The affection is most frequently bilateral. The disease is as frequent in the male as in the female sex, and occurs most frequently in the poorer classes, whose bad dwellings and poor nourishment exercise an injurious influence.

Character of the Secretion.—In chronic suppuration of the middle ear the secretion is mostly purulent or blenorrhœal; it is rarely the case that a transparent colloid mucus is discharged which contains only a small quantity of pus-cells.

The quantity of the secretion is very variable. Sometimes the discharge is very copious, sometimes so trifling that it dries in the ear, and forms darkish green crusts. The discharge is greatest in the scarlatino-diphtheritic form and in cases of extensive granulations in the middle ear, of carious affections in the temporal bone, and in consecutive formation of abscesses in the region of the ear.

The yellowish or yellowish-green colour of the secretion is changed in many ways by admixture with dissolved cerumen, detritus, blood, micro-organisms, and medicaments. Then the discharge has a reddish, brownish, dirty gray, or blackish appearance. In cases of caries the discharge is frequently liquid, similar to flesh-rinsings, and very irritating. The secretion in chronic middle-ear suppuration contains pyogenic micro-organisms, putrefactive bacteria, and vibriones. The penetrating offensive odour of the secretion which often occurs is in most cases the sign of decomposition or the effect of putrefactive bacteria (Löwenberg). It is in nowise a symptom of caries, and occurs not only in neglected cases of discharge, but also when the ear has been carefully cleaned.

Appearance of the Membrana Tympani.—The appearance of the membrana tympani in chronic suppuration of the middle ear varies

so much that we must confine ourselves to a description of its principal types. The formation of a correct opinion as to the appearance is of great importance in this form of inflammation, because successful treatment is prevented by overlooking apparently trifling deep changes.

FIG. 165. — SEMI-LUNAR, JAGGED ORIFICE IN THE ANTERIOR INFERIOR QUADRANT OF THE RIGHT MEMBRANA TYMPANI.
From a preparation in my collection.

FIG. 166. — HEART-SHAPED ORIFICE IN THE RIGHT MEMBRANA TYMPANI.
From a preparation in my collection.

FIG. 167. — LEFT MEMBRANA TYMPANI PERFORATED IN 3 PLACES.
From a preparation in my collection.

When the collected secretion hinders the view of the membrana tympani it must be washed out with antiseptic, lukewarm water, and the remaining fluid removed with cotton-wool.

FIG. 168. — KIDNEY-SHAPED PERFORATION IN THE RIGHT EAR OF A BOY, 10 YEARS OF AGE, WHO SUFFERED FOR 6 YEARS FROM SCARLATINAL SUPPURATION OF THE MIDDLE EAR.
The visible mucous membrane of the tympanic cavity is light-red, the membrana tympani gray, the short process and posterior fold project greatly. Hearing-distance 5 m. for speech.

FIG. 169. — KIDNEY-SHAPED PERFORATION IN THE LEFT EAR OF A WOMAN WHO HAD SUFFERED FOR 3 YEARS FROM A CHRONIC SUPPURATION OF THE MIDDLE EAR.
The mucous membrane of the middle ear is dark-red, the congested membrana tympani is covered here and there with gray epidermis. Hearing-distance: acoumeter 25 cm., speech 65 cm.

During examination with the ear-speculum we must concentrate our attention upon the locality and the size of the perforation, upon the condition of the remains of the membrana tympani and of the inner wall of the tympanic cavity, and lastly upon the coincident changes in the external meatus.

The site of the loss of substance is most frequently the anterior inferior portion of the membrana tympani, and next to that its posterior superior quadrant; Shrapnell's membrane, situated above the short process, is more rarely destroyed.

The size of the perforation varies from that of the prick of a needle to the complete destruction of the membrane. But the extent of the loss of substance depends neither on the duration nor on the intensity of the purulent process. The greatest loss of substance occurs with scarlatino-diphtheritic middle-ear suppuration and in tubercular phthisis of the mucous membrane of the middle ear.

FIG. 170.—DOUBLE PERFORATION OF THE RIGHT SIDE IN A GIRL AGED 18 YEARS, IN WHOM THE DISEASE HAD CONTINUED FOR TWO YEARS WITH OCCASIONAL CESSATIONS.

FIG. 171.—DOUBLE PERFORATION IN A MAN AGED 37, WHO HAD SUFFERED FROM OTORRHŒA FOR MANY YEARS.

FIG. 172.—DOUBLE PERFORATION OF THE LEFT MEMBRANA TYMPANI OF A GIRL, 17 YEARS OF AGE, WHO SUFFERED FROM CHILDHOOD FROM CHRONIC SUPPURATION OF THE MIDDLE EAR.

The form of the orifice is most frequently roundish, oval, or elliptical, more rarely semi-lunar (Fig. 165) or angular. Those situated below the handle of the malleus receive a marked heart or kidney-shape (Figs. 166, 168, 169) from the extremity of the handle projecting into the perforation. The form and size of the aperture, are, however, very changeable in consequence of the varying swelling of its margins. In cases of profuse discharge, particularly, the smaller perforations can hardly be discovered, and the place of perforation may only be recognised by a depression with pulsating light reflex, or through the discharge of pus upon the condensation of air in the tympanic cavity. Perforations on the anterior inferior quadrant of the membrane are often hid by the projecting anterior wall of the meatus, and their presence is only shown by air bubbles at the anterior inferior portion of the field upon condensing the air in the middle ear.

As to the number of perforations, as a rule there is only one aperture in the membrane; but occasionally two perforations will be found (Figs. 170 and 171) of different forms and sizes. Still rarer are the cases in which the membrane is perforated in three (Fig. 167),

four (Bing) or more places (v. Tröltsch, Wreden), or in which the membrana tympani is perforated like a sieve by numerous small orifices, as has been observed (Bonnafont, Schwartze) in diphtheritic and tubercular suppurations of the middle ear.

During the course of the middle-ear suppuration the remainder of the membrana tympani appears through the epidermis lying upon it, whitish, greenish-yellow, or reddish-gray, and is differentiated, even when congested, in most cases from the mucous membrane of the walls of the tympanic cavity which is dark red, or covered by epidermis and exudate. Rarely the cuticular layer is excoriated. The

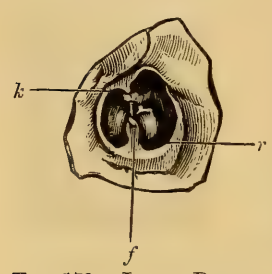

FIG. 173.—LARGE DEFECT OF THE MEMBRANA TYMPANI.
k, Short process of the hammer with the stump of the handle; *f*, tongue-shaped remainder of the membrane adherent to the promontory; *r*, fenestra rotunda. (After a preparation in my collection.)

FIG. 174. — DESTRUCTION OF THE INFERIOR HALF OF THE MEMBRANA TYMPANI, LAYING BARE THE PROMONTORY AND THE NICHE OF THE FENESTRA ROTUNDA. The inferior extremity of the handle of the malleus is destroyed by necrosis; its superior thickened portion with the grayish-yellow remnants of the membrana tympani is preserved. From a man, 24 years of age, who had at times suffered from Otorrhœa from childhood. Hearing-distance: acoumeter = $\frac{2}{3}$ m.; speech = 2 m.

FIG. 175.—GREAT LOSS OF SUBSTANCE IN THE RIGHT MEMBRANA TYMPANI. The inferior portion of the handle of the malleus is laid bare and detached; in the upper portion of the remnant of the membrane is a small gap (*a*); the upper space of the tympanic cavity is filled with masses of connective tissue. From a preparation in my collection.

margin of the perforation is either covered by secretion, or bounded by a red line; sometimes it is covered with small papillæ. It either does not touch the inner wall of the tympanum or may be in contact with it in places. Most frequently the posterior portion of the margin of the perforation is applied to the promontory, while the anterior margin is not in contact, and throws a shadow upon the deeper-lying inner wall of the tympanic cavity. In a few cases I have seen a whitish or reddish string extending from the free remainder of the membrane to the inner wall of the tympanic cavity (Fig. 192). In the case of small perforations the handle of the malleus can but rarely be distinguished, in consequence of the

turgidity of the dermic layer; but when the apertures are larger, and the tissue of the membrane round the handle of the malleus is destroyed, it either protrudes freely into the aperture in its original form and position (Fig. 175), or it appears thickened to several times its normal diameter, drawn inwards, and with its inferior extremity in contact with the inner wall of the tympanum, or it is shortened by carious softening of its inferior extremity (Fig. 174), or wanting altogether.

The changes on the inner wall of the tympanic cavity may only be judged if the perforation is large enough (3 to 4 mm.) to light the tympanic cavity sufficiently. Smaller openings appear after removal

FIG. 176.—THE INFERIOR HALF OF THE LEFT MEMBRANA TYMPANI IS DESTROYED; ON THE DARK-RED INNER WALL OF THE TYMPANIC CAVITY ARE SEVERAL GLOBULAR GRANULATIONS.

From a man, 24 years of age, who had suffered from a discharge from the left ear since he was 5 years old. Hearing-distance: Acoumeter = 0; speech = $\frac{1}{3}$ m. In the remaining upper portion of the membrane the thickened stump of the handle of the malleus is recognisable.

FIG. 177.—GREAT DESTRUCTION OF THE RIGHT MEMBRANA TYMPANI, OF WHICH ONLY A THICKENED REMNANT IS PRESERVED AT THE SUPERIOR PERIPHERY. GROUPS OF SMALL GRANULATIONS ON THE PROMONTORY.

From a girl, 19 years old, who had suffered since childhood from a discharge from the ear. Destruction of the growth by touching it with liq. ferri muriat. The otorrhœa has ceased. Hearing-distance: speech = 2 m.

FIG. 178.—GREAT DESTRUCTION OF THE INFERIOR HALF OF THE LEFT MEMBRANA TYMPANI.

On the promontory is an oblong growth, which appears hard as cartilage when felt with the sound; behind it the niche of the fenestra rotunda. From a man, 33 years of age, in whom the suppuration of the middle ear commenced 24 years before. Hearing-distance: acoumeter = 20 cm.; speech = 1 m.

of the secretion as black holes in the membrane. In the case of more extensive defects, the mucous membrane, which has been laid bare, will be found to be yellowish-red, scarlet or bluish-red of different shades, here and there lustrous, and not unfrequently covered by adherent layers of exudation and epidermis. The tumefaction is either very trifling or so considerable that all the depressions in the tympanic cavity are erased, and the mucous membrane grows through the orifice above the surface of the membrana tympani. Sometimes numerous large and small granulations or polypi (Figs. 176 and 177) are formed, and in some very rare cases fibrous growths

as hard as cartilage or hyperostotic thickening occur, which remain on the inner wall of the tympanic cavity as yellow protuberances after the suppuration has ceased (Fig. 178).

After cessation of the Suppuration.—The outlines and forms of the remaining portion of the membrana tympani and the details of the inner wall of the tympanic cavity come much more distinctly into view. The remains of the membrane are grayish, opaque, thickened and like parchment, and not unfrequently more or less calcified. The calcareous deposits appear as sharply defined chalky-white or yellowish spots between the handle of the malleus and the periphery (Figs. 179, 182, 183), and are sometimes of such size that almost all the remaining portion of the membrane except the peripheral portion of the annulus tendinosus is transformed into a

FIG. 179.—DOUBLE PERFORATION OF THE LEFT MEMBRANA TYMPANI; THE GAPS ARE SEPARATED BY A NARROW BRIDGE; IN FRONT OF THE HANDLE OF THE MALLEUS IS AN OBLONG CALCAREOUS DEPOSIT.
From a preparation in my collection.

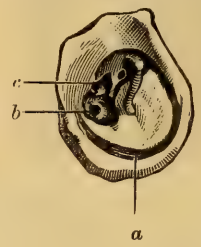

FIG. 180. — EXTENSIVE CALCIFICATION OF THE RIGHT MEMBRANA TYMPANI INVOLVING ALL THE LAYERS.
a, Peripheral portion, not calcified; *b*, Perforation behind the handle of the malleus; *c*, A thin band which connects the partly eroded long crus of the incus with the capitulum of the stapes. From a preparation in my collection.

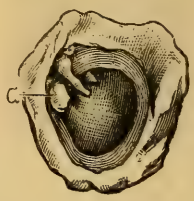

FIG. 181. — GREAT DESTRUCTION OF THE MEMBRANA TYMPANI; THE INFERIOR EXTREMITY OF THE HANDLE OF THE MALLEUS IS LAID BARE.
a, In front of the handle of the malleus is a calcareous deposit, which partially projects freely into the gap. (Left ear.) From a preparation in my collection.

rigid calcareous mass, which has penetrated all the layers (Fig. 180). Rarely a part of the calcified portion projects freely into the orifice of the perforation (Fig. 181).

The handle of the malleus in small perforations is sometimes so embedded in the thickened layers of the membrane that it is either completely invisible, and only the short process is visible as a projecting knob at the anterior superior pole of the membrane, or is only indicated by a diffuse injection of its vascular bundles. In the case of large gaps, when the handle of the malleus is partly stripped of the tissue of the membrane, it but rarely retains its normal position (Fig. 184), inclining more or less towards the inner wall of the

tympanic cavity (Fig. 185), appears shortened, and is adherent with the inner wall of the tympanic cavity. The place of union is situated mostly above the highest point of the promontory, and is indicated by a circumscribed thickening of the adjoining mucous membrane. Where a portion of the handle of the hammer is destroyed by carious degeneration, it appears uneven, pointed, and not unlike a rusty wire tack, or it ends in a stump below the processis brevis.

The changes on the inner wall of the tympanic cavity, after the suppuration has ceased, vary in many ways. The mucous membrane is either rose-red, yellowish-red, or pale yellow, moist and

Fig. 182.—Small Perforation behind the Umbo. Semi-lunar Calcareous Deposit in the Anterior Inferior Half of the Membrana Tympani.

In a girl, 15 years of age, in whom otorrhœa is alleged to have appeared about four months before, and to have ceased in a fortnight. Hearing-distance: watch = 40 c.; speech = 4 m. (Left ear.)

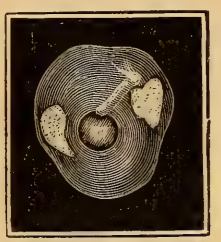

Fig. 183.—Central Perforation; in front of and behind the Handle of the Malleus are Circumscribed Calcareous Deposits in the Membrana Tympani.

In a girl, 17 years of age, in whom the suppuration of the middle ear commenced eight years and ceased two years before. Hearing-distance: speech = 1½ m. (Right ear.)

Fig. 184. — Large Perforation in the Right Membrana Tympani; the Handle of the Malleus is free; the long Crus of the Incus, and the Niche of the Fenestra Rotunda are visible.

From a man, 28 years of age, in whom the suppuration of the middle ear took place in childhood after scarlatina. Hearing-distance: watch = in contact; speech = ⅓ m.

of normal appearance. In the case of cicatricial condensation of the tissue, it appears of a tendinous-gray colour, uneven and lustrous; in calcification of the mucous membrane, it is markedly white. Not unfrequently vascular ramifications can be plainly distinguished on the promontory, most frequently one or two large veins, which accompany Jacobson's nerve (Fig. 186). If destruction of the anterior portion of the membrani tympani (Fig. 187) has taken place, the anterior part of the tympanic cavity, extending to the ostium tympanicum tubæ, will become visible as a dark funnel-shaped depression. If the orifice extends nearly to the lower periphery of the membrane, a portion of the obliquely-placed inferior wall of the tympanic cavity, with its ridgy protuberances and dark depressions, will frequently also come into view (Fig. 188). The

knowledge of this appearance is important, because these osseous projections might be mistaken for trabecular outgrowths of the mucous membrane in the tympanic cavity. In the case of large perforations on the posterior half of the membrane (Figs. 189, 190), the promontory will be seen projecting forward like a hillock. Above the detached articulation of the stapes and the incus (Fig. 189), or in cases in which the inferior portion of the long crus of the incus is eroded, the two crura of the stapes and its round capitulum (Figs. 190, 191), with the tendon of the stapedius extending backwards, more rarely the chorda tympani, come clearly into view, as also at the posterior boundary of the promontory the dark niche of the fenestra rotunda.

Diagnosis of Perforation of the Membrana Tympani.—Besides the

FIG. 185.—LARGE PERFORATION OF THE MEMBRANA TYMPANI; THE HANDLE OF THE MALLEUS IS FORESHORTENED; ITS INFERIOR EXTREMITY IS IN CONTACT WITH THE PROMONTORY.

From a young man, 19 years of age, who was affected with purulent inflammation of the middle ear during scarlet fever, ten years ago. Hearing-distance: acoumeter = 1 m.; speech = 1½ m.

FIG. 186.—KIDNEY-SHAPED PERFORATION BELOW AND BEHIND THE HANDLE OF THE MALLEUS; BEHIND IT IS THE NICHE OF THE FENESTRA ROTUNDA.

From a girl, 20 years of age, in whom the suppuration appeared in childhood, and ceased two years ago. Hearing-distance: acoumeter = 1 m.; whispered speech = 6 m. (Right ear.)

FIG. 187.—LARGE PERFORATION IN THE MEMBRANA TYMPANI IN FRONT OF THE HANDLE OF THE MALLEUS.

From a girl, 18 years of age, who had suffered from a discharge from the ear since childhood. Hearing-distance: watch = 4 cm., speech = ⅓ m. (Right ear.)

appearances here described, as seen through the aural speculum, the noise of the air rushing through the perforation during the air-douche is an important objective sign in ascertaining that the membrane is perforated. In the secreting stage it will be heard as rattling, after the suppuration has ceased as a high-pitched hissing sound. A simple experiment, by which the presence of a perforation can be ascertained, consists in filling the external meatus with warm water, and injecting air into the middle ear, when air-bubbles will appear on the surface of the fluid. Where there is no perforation-sound heard by auscultation upon condensing the air in the middle ear, one should try the condensation of air in the external

meatus, and the auscultation by means of a tube placed in the nostril (p. 126).

The diagnosis of perforation of the membrane is made much more difficult when the loss of substance is closed by exudation, or is overgrown by granulations, or when the margins of the perforation are applied to the inner wall of the tympanic cavity, and the sharply-defined boundary between the membrana tympani and the mucous membrane of the tympanum is wanting. In such cases the seat of the perforation is often only learned after repeated observa-

FIG. 188.—EXTENSIVE PERFORATION OF THE RIGHT MEMBRANA TYMPANI, OF WHICH ONLY A SMALL BORDER IS PRESERVED AT THE PERIPHERY.

The inferior extremity of the handle of the malleus is anchylosed with the inner wall of the tympanic cavity. The round capitulum of the stapes, the niche of the fenestra rotunda, and the ridgy protuberances of the lower wall of the tympanic cavity are visible. From a young man, 17 years of age, in whom the suppuration commenced in childhood during scarlatina, and lasted until 3 years ago. Hearing-distance: watch = 2 cm.; speech = $\frac{1}{2}$ m.

FIG. 189. — PERFORATION OF THE POSTERIOR HALF OF THE RIGHT MEMBRANA TYMPANI.

Behind the umbo is the strongly projecting yellowish-gray promontory, above it the long crus of the incus lying free and the posterior crus of the stapes. From a young man, 16 years of age, in whom the purulent inflammation commenced 2 years ago after a cold bath. After the removal of a small polypus seated on the promontory, the suppuration ceased. Later on the orifice was closed by a large thin cicatrix. Hearing-distance: acoumeter = 1 m.; speech = nearly normal.

FIG. 190.—EXTENSIVE PERFORATION IN THE POSTERIOR AND INFERIOR PORTION OF THE RIGHT MEMBRANA TYMPANI.

In the posterior superior quadrant of the field of view the capitulum of the stapes with the tendon of the stapedius, below it the pale yellow promontory, and behind it the niche of the fenestra rotunda are visible. From a man 50 years of age.

tions during the course of the disease, when the swelling of the membrane decreases, and the mass of exudate or epithelium is cast off. In questionable cases we may often learn the seat of the perforation by means of the Siegle speculum. If the air in the external meatus is rarefied, a drop of pus will often be seen, which will signify the place of perforation. On the other hand, when the air is condensed in the meatus, the opening may be seen for a moment as air passes through. The pneumatic speculum is also of use when there is doubt if an uneven granular surface occupying the

whole field of vision is the rough surface of the membrana tympani, or the inner wall of the tympanic cavity. In the latter case there is no movement on the field of vision upon condensing the air in the meatus.

On the other hand, in extensive perforations of the membrana tympani the congested mucous membrane of the inner wall of the tympanic cavity, or, after the suppuration has ceased, the tendinous gray, lustrous cicatricial tissue covering it, may be thought to be the membrana tympani, if the ledge-shaped remnants of the membrane which still exist at some parts of the periphery, or the stump of the handle of the malleus, did not show by their position in relation to

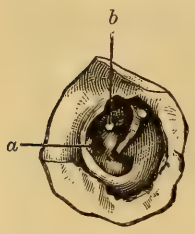

FIG. 191. — PERFORATION OF THE POSTERIOR HALF OF THE RIGHT MEMBRANA TYMPANI.
a, Fenestra rotunda ; *b*, The capitulum of the stapes, with the tendon of the stapedius laid bare by the destruction of the long crus of the incus. From a preparation in my collection.

FIG. 192. — EXPOSED CHORDA TYMPANI IN A CHILD AGED 9 YEARS.
Otorrhœa commenced four years ago, and ceased half a year ago. By touching the string a sticking and sour taste is felt on the tip of the tongue.

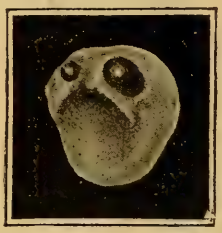

FIG. 193. — PERFORATION IN THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI AND OF THE MEMBRANA SHRAPNELLI.
In a man, aged 21 years, who has had otorrhœa for five years. Complete deafness of the left ear.

the deeper-lying field of view that the latter belongs to the inner wall of the tympanic cavity.

Perforation of Shrapnell's Membrane.—The middle-ear suppuration accompanied by perforation of Shrapnell's membrane deserves a special consideration as well from a diagnostic as from a therapeutic point of view. They are, judging from the results of my dissections, much more frequent than was formerly supposed, as owing to being covered with macerated epidermis and swelling of the surrounding portions, they are obstructed from clinical observation.

There is no doubt from anatomical and clinical observation that purulent inflammation limited to the external attic takes place with perforation of Shrapnell's membrane, without the inflammation spreading to the rest of the tympanic cavity. In the majority of cases, however, the perforation of Shrapnell's membrane is caused by a purulent inflammation spread over the whole middle ear ; but in the course of the process the suppuration in the middle ear may

cease, while it obstinately continues for a long time in the system of cavities bordering on Shrapnell's membrane. In this space also small polypi sometimes appear, which press through the perforated membrane into the external meatus (Cl. Blake), and frequently caseous or cholesteatomatous masses (Bezold) will be found here, while they are absent from the remaining portions of the tympanic cavity.

The perforation of Shrapnell's membrane occurs either alone or accompanied by a second opening on the membrana tympani (Fig. 193). During the Valsalvan method pus or air very rarely penetrates through the perforation. This is explainable, when one

FIG. 194.—DESTRUCTION OF SHRAPNELL'S MEMBRANE ON THE LEFT SIDE.

On the incisura Rivini is a large jagged gap in the bone, through which the mucous membrane of the tympanic cavity is growing. From a girl, 16 years old, in whom suppuration of the middle ear had existed for four years in both ears. Lately she had had continuous headaches and twitchings of the facial muscles. In spite of repeated removal of the protruding new formation, it again and again grew out into the external meatus. But after several injections of warm water into the tympanic cavity by means of the catheter, the suppuration rapidly decreased, and healing occurred.

FIG. 195.—GAP OF THE SIZE OF A SMALL PEA ABOVE THE SHORT PROCESS, THE BASE OF WHICH IS LINED BY A SMOOTH, DRY AND GRAY CICATRIX.

From a girl, 20 years old, who had suffered from ear-affection from childhood. The suppuration is localized to the space above the short process. The suppurating cavity was cleansed by means of a small tympanic tube, inserted from the meatus, and then a few drops of a ten per cent. solution of nitrate of silver were injected through the same tube, by which the secretion was arrested on the following day. Several subsequent slight relapses were quickly disposed of by the same treatment. Hearing-distance: acoumeter, 11 cm.; speech, $1\frac{1}{2}$ m.

considers that the slight communication between the attic and tympanic cavity is generally closed by swelling, hypertrophy, and masses of secretion (Morpurgo). The membrana tympani itself is sometimes moist, tumefied, and secreting; sometimes again dry and lustreless, especially in those cases in which the pus is confined to the already-mentioned system of cavities.

The suppurations of the middle ear, accompanied by perforations of Shrapnell's membrane owing to the stagnation of the secretion, are characterized by their tediousness and obstinate course (Blake,

Burnett, Orne Green, Buck). If suppuration continues long in this situation it leads not unfrequently to caries of the malleus and incus, and to absorption of the osseous tissue above the Rivinian fissure, producing gaps above the short process in the upper wall of the external meatus, which in some cases become so extensive that a large portion of the attic comes clearly into view.

The appearance in cases where such gaps have been formed varies according to the anatomical condition of the membrana tympani, and whether the suppuration still continues or has ceased. Where there is still secretion present it is occasionally possible, after carefully cleaning the meatus, to see the sharply-marked defect in Shrapnell's membrane, or the opening produced by destruction of the bone above this, and to judge of the character of the base of the

FIG. 195.—A LARGE DEFECT IN THE BONE ABOVE THE RIVINIAN SEGMENT, THROUGH WHICH THE HEAD OF THE HAMMER IS VISIBLE.
In a woman, aged 30 years, who had suffered from otorrhœa since 10 years of age. Whispering = 2½ m.

FIG. 197. — LARGE DEFECT IN THE BONE AT THE INNER BOUNDARY OF THE SUPERIOR WALL OF THE MEATUS.
In a girl, 26 years of age. The head of the malleus, the ligam. mallei ant., and the body of the incus with the long process could be seen. A very thin membrane closes the gap. Hearing-distance: acoumeter = 50 cm.; whispered speech = 5 m.

cavity. More often, however, the opening is so covered and overgrown that its position may only be proved after a longer observation.

A much clearer insight into the state of the deeper parts can be obtained when the secretion has ceased. If the gap is small, the background is seen to be formed by a tendinous gray cicatrix (Fig. 195), or the bared neck of the malleus and a portion of the head of the malleus are exposed to view. But if the defect in the bone is of greater size the articulation of the malleus and incus is sometimes so completely exposed that it can be minutely examined in all its anatomical details (Fig 197).* In several cases in which the incus was destroyed, I have seen the exposed head of the malleus (Fig. 196); if this was also destroyed a view could be obtained of

* Compare my *Beleuchtungsbilder des Trommelfells*, p. 122.

the fenestra ovalis, the Fallopian canal situated above it, and in the case of gaps of still larger size and extending more backwards, even the upper part of the horizontal semicircular canal. The membrana tympani is generally gray and opaque, sometimes thickened, and either completely or partially adherent to the inner wall of the tympanic cavity. As to the results of this peculiar form of perforation, which requires a special treatment, we will return to it later.

Pathological Changes in the External Meatus.—In chronic middle-ear suppuration there occasionally occurs follicular or diffuse inflammation in the meatus; complete exfoliation of the epidermic layer, laying bare the papillary stratum; hypertrophy of the cutis, and consequent narrowing of the meatus and the formation of granulations and polypi. More rare results of chronic middle-ear suppuration in the external meatus are: inflammation and thickening of the periosteal portion, ending in hyperostosis and exostosis; farther, the formation of ulcers and erosions in the external meatus (in scrofulous persons), caries and necrosis of the osseous walls, and necrosis of the cartilaginous meatus.

On the auricle and around the ear, especially in children and in persons with a tender, irritable skin, the action of the secretion produces a moist eczema, sometimes deep-seated ecthymatous pustules, and sometimes a chronic diffuse dermatitis with enlargement of the thickened and hardened auricle. A frequent phenomenon, especially in children, is the swelling of the cervical and submaxillary glands, and more rarely the lymphatic glands behind the ear. The glandular infiltration is in most cases due to the vicinity of the seat of suppuration, and the assumption of a scrofulous basis is only justifiable if other characteristic signs of scrofula are also present. Also the secretion of the ceruminal and sebaceous glands in the external meatus is often altered by chronic middle-ear suppuration, and one finds after this disease, in place of the normal secretion, a crumbling, scaly secretion, or an excessive growth of the epidermis of the meatus, which extends into the tympanic cavity through the perforation and is conducive to the formation of cholesteatoma, which will be described later.

Symptoms.—Chronic suppuration of the middle ear runs its course frequently without any striking subjective phenomena. Pain is a frequently-recurring symptom during the intercurrent acute inflammations of the middle ear, and in the secondary inflammations of the external meatus; it is also felt in cases of stagnation of pus in the tympanic cavity, due to a temporary closure of the margins of the perforation, to stricture of the meatus, or to polypi. When pus or decomposed cheesy masses become sacculated in the tympanic cavity and in the mastoid cells, when the mucous membrane is ulcerated and in carious affection of the osseous walls of the middle ear, the pain is severe. The pain is seldom produced by neuralgia.

More frequently suppuration of the middle ear is accompanied by

a number of unpleasant head symptoms, such as oppression and heaviness in the head or obstinate headache, which are either caused by increased pressure in the labyrinth, or by the hyperæmia which is transmitted to the scalp. If one ear alone is diseased, as a rule only the corresponding side of the head or the occiput is affected. These symptoms are most frequently observed when the escape of the pus is mechanically obstructed, or when inspissated masses have accumulated in the middle ear; not unfrequently, however, they are due to nervousness or anæmia. Giddiness or attacks of dizziness with vomiting, unsteadiness of the gait, and increased tinnitus, are not common in middle-ear suppuration, unless accompanied by caries.

The unpleasant head symptoms disappear as a rule after the suppuration has ceased. A surprisingly rapid relief takes place, especially after the removal of inspissated secretion and polypi from the middle ear. Cases are, however, observed in which, on the contrary, when the secretion has completely ceased, a continuous headache or sense of oppression is developed on the corresponding side of the head or in the whole head, which only disappears when the purulent secretion returns.

Subjective sensations of hearing are much less common in chronic suppuration than in the chronic catarrhs of the middle ear. The reason for this is, that when the membrane is perforated, an equalization of the air-pressure takes place through the orifice. The noises are mostly intermittent, but are sometimes continuous in syphilitic affections or in very old adhesive processes, and are considered a bad prognostic sign as regards the restoration of hearing.

Alteration of taste, decrease or complete loss of it owing to diseased changes in the chorda tympani (Moos, v. Tröltsch) and in the glosso-pharyngeal, which takes part in the formation of the tympanic plexus (Aug. Carl, Observation on himself, *Z. f. O.*, Bd. viii.), are, as Urbantschitsch (*Beob. über Annalen des Geschmacks*, etc., Stuttgart, 1876) observes, very frequent in chronic middle-ear suppuration, and extend to the soft palate, posterior wall of the pharynx and the mucous membrane of the cheeks. It is, nevertheless, striking that, remarkable as the alteration in this sense may appear when tested, patients never complain of such a change when eating or drinking, even though both ears are suppurating. In the same manner, though not in the same proportions, an alteration in the sense of touch in the tongue is observed.

An alteration in the sense of smell, as diminished sensibility to certain smells, or anosmia, is frequently observed, which often may be traced to a simultaneous naso-pharyngeal affection or paresis of the olfactory nerve, though sometimes occurring without demonstrable disease of the pituitary membrane.

Hearing Disturbances.—In the course of chronic suppuration of

the middle ear the hearing-power presents great fluctuations, which depend partly on the varying degree of swelling of the mucous membrane and on the patency of the Eustachian tube, partly on the quantity of secretion in the tympanic cavity. Changes in the weather and in the temperature exert a marked influence upon the hearing-power. Warm and dry weather have a beneficial influence upon the hearing, while cold and damp weather have a detrimental effect. A temporary or even lasting impairment of hearing takes place in cases of recurrent inflammation of the middle ear, in intercurrent naso-pharyngeal catarrh, in serious illnesses, in marasmatic disease, and in general syphilis. Slight fluctuations in the hearing-distance are observed in cases of excessive proliferation of the mucous membrane of the middle ear, by which the ossicula are enclosed on all sides, also in cases of rigid adhesion or anchylosis of the ossicula and in advanced labyrinthine affections.

The degree of deafness after the suppuration has ceased depends upon the pathological changes which have been produced by the inflammatory process in the middle ear. If the swelling and loosening of the mucous membrane subsides after the suppuration has ceased an improvement in the hearing always takes place, and the hearing, in spite of persistent changes in the membrana tympani, may become nearly normal. If, however, the ossicula are fixed by those soft or cicatricial new-formations previously mentioned, if especially the niches of the two labyrinthine fenestræ are filled by the proliferating mucous membrane, and the stapes is thereby firmly fixed, the cessation of the discharge will not produce any improvement in the hearing, or only a slight one. It even happens, that immediately after the suppuration has ceased a remarkable change for the worse in the hearing is noticeable, which only disappears with the recurrence of the discharge. This fact can only be explained by retraction of the new-formed connective tissue of the previously swollen and hypertrophied mucous membrane after the secretion has ceased, by which the ossicula become more rigidly fixed, while the connective tissue is relaxed by a return of the purulent inflammation and the ossicula become more movable.

The power of perception of the auditory nerve through the cranial bones in cases of chronic suppuration of the middle ear is, in the majority of patients, normal. But in advanced age, or in the case of long-existing adhesive changes, which date from earliest childhood, in simultaneous syphilitic labyrinthine affection, and where there are constant intense subjective noises, the perception of sound through the cranial bones is diminished or completely absent. The results of Weber's test are generally the same as in middle-ear catarrh; this is also true of Rinne's and Schwabach's tests (p. 143).

Course and Results.—The course of chronic purulent inflammation of the middle ear depends upon the original cause of the affection, upon the local changes present in the ear and in the naso-pharyngeal mucous membrane, and on the state of the general health. Con-

sidering the great variety which this form of disease shows in regard to its issues and consequences, we must confine ourselves to a general description.

Regarding the suppuration itself, it continues generally without interruption in the scrofulous, tubercular, or scarlatinal forms, and in cases of diffuse granulations, of polypi and of caries. Very frequently, however, the secretion ceases spontaneously and completely, to return again after a short pause or after an interval of years, with or without the symptoms of an acute inflammation. Relapses are caused most commonly by catching cold, by the entrance of water into the meatus while washing or bathing, by intercurrent naso-pharyngeal catarrhs and bronchitis, or by organic, or general febrile diseases. Relapses are specially frequent when the perforation of the membrane has not been closed by a cicatrix, when, therefore, the bare mucous membrane of the tympanic cavity is exposed to the immediate action of external sources of injury. The seasons also exert an influence upon the purulent process, especially in children, in whom an arrest of the suppuration is frequently observed in spring, to return again in autumn.

The suppurative process as a rule ceases uniformly over the whole mucous membrane of the middle ear and on the membrana tympani. But cases are frequently seen in which the remnant of the membrana tympani is dry and lustrous, while the inner wall of the tympanic cavity is still covered by pus, and *vice versâ*. In like manner, in cases of extensive deficiency of the membrana tympani, circumscribed parts of the mucous membrane of the tympanic cavity are found to be covered by a dry, lustrous, cicatricial tissue, while other portions are still covered by pus, after the removal of which a tumefied or granulating patch of mucous membrane will be observed.

The result obtained by examination with the speculum varies greatly during the continuance of the suppuration. Frequently the field illuminated remains unchanged for years; often, however, even after a short time, especially after intercurrent acute relapses, it presents an appearance materially different from that at former examinations. Sometimes even after the space of a few weeks a great enlargement, rarely a decrease, of the perforation will be seen, or adhesive cicatrization between the membrana tympani and the deeper portions of the tympanic cavity occurs. The field of view may also appear to be totally changed by a rapid growth of granulations and polypi in the middle ear, which occurs most frequently among individuals with some dyscrasia. Occasionally the perforation changes its position, as it may wander from in front backwards, seldom in the opposite direction.

The results of chronic suppurative middle-ear inflammation are: 1. Healing after the cessation of suppuration with complete restoration of the hearing. 2. Disturbance of hearing of different degrees, even to complete deafness owing to adhesive formation of connective tissue in the tympanic cavity and in the niches of the fenestræ through which the ossicula are fixed, and the membrane of the fenestra rotunda is abnormally weighted. 3. Desquamation and formation of cholesteatoma in the external meatus and in the middle ear. 4. The ulcerative and carious necrotic processes in the temporal bone and their results.

We will next discuss the formation of cicatrices on the membrana tympani, the adhesive processes after middle-ear suppuration, the

Fig. 198.—Perforation in the Anterior Inferior Quadrant of the Left Membrana Tympani.

From the posterior margin of the defect there extends cicatricial tissue, which does not yet quite close the gap. Behind the handle of the malleus is an irregular calcareous deposit. From a man, 64 years of age. Duration one year. After treating it for a fortnight the suppuration ceased. Hearing-distance: speech = 5 m.

Fig. 199.—Kidney-shaped Cicatrix below the Handle of the Malleus.

From a woman, 48 years of age, in whom purulent inflammation of the middle ear commenced 2 years before, but ceased after a few weeks. Great deterioration in the hearing-power after closure of perforation. Hearing-distance: watch = in contact with auricle; speech = 1 m.

persistence of openings in the membrana tympani, and the cholesteatoma of the ear.

1. *The Closure of Perforations with Cicatricial Tissue.*

The closure of the perforation by cicatricial tissue depends neither on the duration of the discharge nor on the amount of the loss of substance. In general, however, small losses of substance are more frequently closed through cicatrization than more extensive ones.

The cicatrization takes place either uniformly from the margins of the perforation until the gradually diminishing orifice is closed (Fig. 198), or a ligamentous bridge is formed across the gap, the margins of which unite with those of the perforation, forming a cicatrix which completely fills up the orifice.

Rumler's experiments on animals (*A. f. O.*, Bd. 30), according to which

cicatrization took place from the external layer of epithelium, do not apply to all cases, for I could demonstrate the growth of the cicatricial tissue from the mucous layer of the membrana tympani in sections of several preparations in my collection.

The cicatrices of the membrana tympani appear as sharply-defined dark spots, variable in size, mostly depressed, at the base of which an irregular reflection of light is visible. Their form is roundish or elliptical (Fig. 199), frequently kidney-shaped (Fig. 200), and rarely angular. As a rule only one cicatricial depression exists on the membrana tympani, but not unfrequently two (Fig. 200) or more cicatrices or cicatrix-like depressions are visible on the membrane, of which many are undoubtedly due to partial atrophy of the remaining membrane. The tissue of the membrane in the neighbourhood of the cicatrix is more or less opaque, and here and there thickened, and calcified to a varying extent (Figs. 201 and 203).

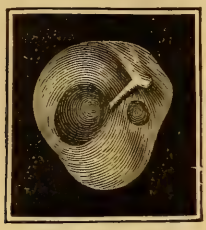

FIG. 200.—LARGE CICATRIX BEHIND THE HANDLE OF THE MALLEUS.
In a man, who suffered in childhood from otorrhœa on the right side. While under observation a cicatrix-like atrophy arose in front of the handle of the malleus. Hearing-distance: watch = 0; speech = $\frac{1}{3}$ m.

FIG. 201.—CICATRIX OF THE SIZE OF A PIN-HEAD, SURROUNDED BY A CALCIFIED PORTION OF THE MEMBRANE IN FRONT OF THE HANDLE OF THE MALLEUS; BEHIND IT, A SEMI-LUNAR CALCIFICATION.
From a man, 50 years old, who had a discharge from the ear in childhood, but who experienced a disturbance of hearing only half a year ago. Hearing-distance: acoumeter = $\frac{1}{3}$ m.; speech = $4\frac{1}{2}$ m.

A difference is made between free, applied, and adherent cicatrices. As a rule only small cicatrices are free, as they rarely move inwards so far as to come into contact with the inner wall of the tympanic cavity. Cicatrices of a larger size, however, are almost always applied so closely to that wall that the details of the promontory, the niche of the fenestra rotunda, the connection between the stapes and incus, or the head of the stapes alone, appear nearly as distinctly as in extensive losses of the membrana tympani.

The cicatrices of the membrana tympani remain either unchanged after the closure of the perforation or increase in size later. I have repeatedly observed a change in position of the cicatrix upon the

membrane; destruction of the cicatrix, with return of the perforation, occurs in many cases.

The diagnosis of cicatrices of the membrana tympani is generally easy. Small, sharply-defined, and dark cicatrices certainly may at first sight look to the inexperienced eye like perforations. But the absence of the noise produced in perforation during condensation of air in the middle ear, and the subsequent globular curvature of the depression outwards above the level of the other portions of the membrane, will at once lead to the recognition of the cicatrix. Moreover, free cicatrices present during an act of deglutition or during quiet respiration (Blake's manometrical cicatrix) a remarkable mobility. Upon testing with Siegle's speculum the cicatrices

FIG. 202.—LARGE HEART-SHAPED CICATRIX BELOW THE HANDLE OF THE MALLEUS; BEFORE AND BEHIND IT TWO SHARPLY DEFINED CALCAREOUS SPOTS.

From a girl, 19 years old, who suffered from a discharge from the ear from childhood until 6 years before. Hearing-distance: watch = 25 cm.; speech = 2 m.

FIG. 203.—LARGE CICATRIX BEHIND AND BELOW THE HANDLE OF THE MALLEUS.

From a man, 34 years old; duration since childhood. After propelling air into the middle ear, the cicatrix, lying against the wall of the tympanic cavity, bulges forward in the form of a bubble towards the external meatus. Hearing-distance: acoumeter = 2 cm.; speech = $\frac{1}{2}$ m.

show an extraordinary movement. Larger, thin cicatrices lying upon the inner wall of the tympanic cavity may be known by the glancing folds extending from the former edge of the perforation, and the bullous irregular bulging after an injection of air into the middle ear, after which the former view of the inner wall of the tympanic cavity also disappears. The latter method is especially valuable for diagnosis in those cases in which the lateral portion of cicatrix, similar to a cul-de-sac, is hidden by the remainder of the membrane (Fig. 204). Cicatrices which extend over the posterior half of the membrane are frequently bulged forward by the air-douche for a short time to such an extent that the handle of the malleus is mostly hidden by this bubble-shaped protuberance.

The free cicatrices alone seldom produce much disturbance in hearing, and we are only justified in assuming that the deafness is

due to the cicatrix, if after it is forced outward by the air-douche (when catarrhal disturbances are wanting) an improvement in hearing occurs, which disappears when the cicatrix again retracts.

The cicatrices lying upon the promontory are usually accompanied by deafness. Often a marked improvement in hearing occurs if the cicatrix is forced outward by the air-douche. It is only when there is a discontinuity between the incus and stapes, in which the cicatrix lying upon the stapes transmits the waves of sound directly, that the bulging of the cicatrix outwards can produce a transient decrease in hearing.

FIG. 204. —DIAGRAMMATIC SECTION IN WHICH THE POSITION OF AN EXTENSIVE CICATRIX OF THE MEMBRANA TYMPANI, IN CONTACT WITH THE INNER WALL OF THE TYMPANIC CAVITY, IS ILLUSTRATED.

a, Ledge-shaped remnant of the membrane ; *b*, *c*, The lateral portions of the cicatrix, extending from the remnant of the membrane to the inner wall of the tympanic cavity ; *d*, Portion of the cicatrix applied to the inner wall of the tympanic cavity.

FIG. 205. — DETACHMENT OF THE HANDLE OF THE MALLEUS FROM THE MEMBRANA TYMPANI.

a, Membrana tympani ; *b*, Inferior extremity of the handle of the malleus, detached from the membrana tympani.

In larger central defects the cicatrization takes place, in some cases, without being connected with the strongly retracted handle of the malleus. This detachment of the handle of the malleus often occurs in membrana tympani which are softened by inflammation during the suppuration, from the traction of the tensor tympani muscle. The separation is either complete, or there remains connective-tissue bridges or strings (Fig. 205) between the handle and membrana tympani. Detachment of the upper portion of the handle with the short process, while the lower spatular end remains adherent to the membrane, as shown in preparations by Moos and Politzer, is rare. Once I found the detached handle of the malleus projecting into the lumen of the meatus, while the cicatricial membrane, not adherent, lay inside of this.

The detachment of the handle of the malleus can only be diagnosed in the living if the upper part of the handle is in its proper position, while the navel of the membrane is very much flattened, and shows excessive movement with

Siegle's speculum. That by detachment of the handle of the malleus the transmission of sound from the membrane to the ossicula is much diminished, is self-evident.

2. *Adherent Cicatrices; Adhesion between the Membrana Tympani and the Inner Wall of the Tympanic Cavity; New Connective-tissue Formation in the Tympanic Cavity.*

It is different in those cases in which the cicatrix on the membrane is adherent to the inner wall of the tympanic cavity. Such adhesions are produced either by immediate contact of the inflamed surfaces, or by proliferation of the mucous membrane of the middle ear, which brings about contact between the walls of the tympanic cavity, the ossicula, and the membrana tympani.

FIG. 206.—ADHERENT CICATRICES IN THE MEMBRANA TYMPANI BELOW THE HANDLE OF THE MALLEUS, WITH A REDDISH-GRAY BACKGROUND. From a girl, 10 years old, who suffered, when from one to two years old, from otorrhœa, as a sequel to measles. Hearing-distance for the watch = 2 cm.; for loud speech = 1 m.

FIG. 207.—DIAGRAMMATIC SECTION THROUGH THE EXTERNAL MEATUS AND THE TYMPANIC CAVITY, SHOWING THE ADHESION OF A CICATRIX, SITUATED BELOW THE HANDLE OF THE MALLEUS, TO THE INNER WALL OF THE TYMPANIC CAVITY.
a, Membrana tympani; *b*, Cicatrix adhering to the promontory.

FIG. 208.—ADHESION OF A CICATRIX OF THE POSTERIOR SUPERIOR QUADRANT OF THE MEMBRANA TYMPANI WITH THE HEAD OF THE STAPES. IN FRONT AND BELOW IS A SMALL PERFORATION. In a girl, aged 18, who had otorrhœa since infancy. Acoumeter = 3 cm.; conversation, 1¼ m.

Small cicatrices rarely adhere to the inner wall of the tympanic cavity. In cases where this takes place the cicatrix forms a cone, narrowing inwards with a black or reddish background, which remains immovable or nearly so during condensation of air in the middle ear, as well as during the examination with Siegle's speculum. Such circumscribed conical adhesions I have rarely found in front of the malleus, oftener below and behind it (Figs. 206 and 207), but most frequently in the posterior superior quadrant of the membrane, in which case the articulation of the incus with the stapes or the head of the stapes alone was united with the cicatrix.

Adhesion of the cicatrix takes place much more frequently when

the cicatrix is extensive, such cicatrices being applied in great part to the inner wall of the tympanic cavity.

The adhesion takes place generally during the stage of secretion, more rarely after the suppuration has ceased. Frequently obstinate cases of suppuration of the middle ear cease after adhesion of the cicatrix of the membrana tympani to the inner wall of the tympanic cavity; more frequently, however, the suppuration continues uninterruptedly, or ceases in some portions which are closed by the adhesions, while it continues the more obstinately in other portions. By examination with the speculum the adherent places do not change their position either on using the air-douche or by testing with the Siegle speculum, while the portions of the membrane not adherent show great movement. The border between the free and

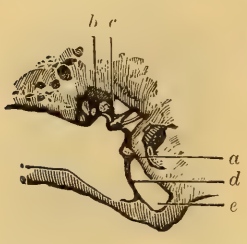

FIG. 209. — HORIZONTAL SECTION THROUGH THE MEATUS AND TYMPANIC CAVITY.

d, Free anterior portion of the membrana tympani; *b*, Cicatrix adherent to the posterior and inner wall of the tympanic cavity; *c*, Head of the stapes grown into the cicatrix.

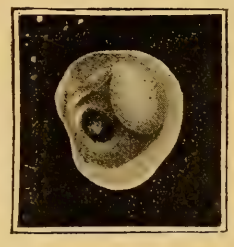

FIG. 210.—PERFORATION IN THE ANTERIOR FREE PORTION OF THE MEMBRANA TYMPANI. THE POSTERIOR SUPERIOR PORTION IS ADHERENT TO THE PROMONTORY.

In a woman, aged 28, who had otorrhœa from childhood. Acoumeter = $\frac{1}{2}$ m.; whispering = $\frac{1}{4}$ m.

FIG. 211.—FRONTAL SECTION THROUGH THE MEATUS AND TYMPANIC CAVITY.

a, Sickle-shaped remainder of the membrana tympani; *b*, Cicatrix which extends inwards with a sharp bend and is lying upon the promontory.

adherent portions is often marked by a white or gray line, at which the movements of the non-adherent portions are sharply limited.

The adhesive processes produced by suppuration of the middle ear show so many anatomical variations that one appearance of the parts rarely completely coincides with another. Considering, however, the practical importance of the subject, we will here briefly describe the appearances which are more frequently met with in the adhesive processes.

Most frequently a cicatrix, extending over the posterior half of the membrana tympani, is found to be adherent to the posterior and inner wall of the tympanic cavity (Figs. 208 and 209). Characteristic of this condition is the sharp half-moon shaped limitations of the remainder of the membrane from the cicatrix, the

sharp edges of the promontory, the niche of the fenestra rotunda, the articulation of the stapes and incus, or the head of the stapes alone if the long process of the incus has been destroyed. Sometimes one finds besides the adhesion of the posterior half of the membrane, a perforation of the anterior free portion (Fig. 210).

Large cicatrices comprising nearly the whole membrana tympani, and adherent to the inner wall of the tympanic cavity, form a cul-de-sac by which the lower and middle portion of the tympanic cavity is separated from the Eustachian tube, mastoid antrum and the upper tympanic cavity. Sometimes there exists with this cul-de-sac a communication between the tube and upper tympanic cavity, as may be proved by auscultation. Often, however, as is shown by several preparations in my collection, the portion of the tympanic cavity lying outside the cul-de-sac is completely filled with connective tissue, and the entrance of air into the middle ear is impossible.

By inspection of extensive adherent cicatrices of the membrana tympani, the usually thickened, strongly retracted handle of the malleus is very marked above the level of the cicatrix. The outlines of the inner wall of the tympanic cavity are more or less clearly defined. The remaining portions of the membrana tympani either go gradually into the cicatrix without a visible outline or they form a sharp angle at their junction. The surfaces of adherent cicatrices appear either dry and shining or moist.

The diagnosis of adherent cul-de-sac shaped cicatrices will be made from the results of ocular examination, the slight movement upon examination with Siegle's speculum, and by touching the depressed portion with a sound. If the portion which remains immovable, upon forcing air into the middle ear and with the Siegle speculum, proves upon touching with the sound to be hard and bony, the adherence of the cicatrix to the osseous wall is probable. If some portions of the membrana tympani are yielding, it cannot be said that no adherence exists between the yielding portion and the inner wall of the tympanic cavity, as occasionally the connective tissue which produces the adherence (as in several preparations in my collection) consists of bands stretched between the membrane and the inner wall of the tympanic cavity, and proves elastic upon examination.

The diagnosis of adherent cicatrices is rendered very difficult when the continuity of the remnant of the membrana tympani with the cicatrix is not apparent, and when in addition the cicatricial tissue extending in front of the ost. tymp. tubæ is ruptured so that the air can freely pass from the Eustachian tube into the external

meatus. This causes the non-adherent portions to remain immovable when air enters the tympanic cavity. In larger defects of the membrane often only some portion of the posterior (Fig. 212), lower or anterior remnant of the membrane is fastened to the inner wall of the tympanic cavity by means of cicatricial tissue, and the diagnosis of such cases is usually not difficult.

Of special interest are those partial cicatrices which extend from the anterior margin of the perforation to the inner wall of the tympanum, and form a partition between the ost. tymp. tubæ and the tympanic cavity. The diagnosis of such membranous septa can only be made with certainty if (Fig. 213) the deep-seated, darkish-gray cicatrix can be seen through the perforation bulging

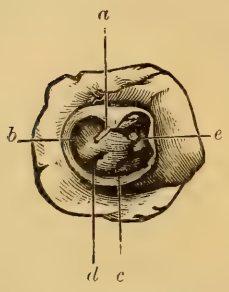

FIG. 212.—LARGE APERTURE IN THE LEFT MEMBRANA TYMPANI.
a, Handle of the malleus; *b*, Free remnant of the membrana tympani; *c*, Adherent cicatrix, extending from the posterior remnant of the membrana tympani to the inner wall of the tympanic cavity; *d*, Free margin of the cicatrix; *e*, Capitulum of the stapes.

FIG. 213.—MEMBRANOUS SEPTUM BETWEEN TYMPANIC CAVITY AND EUSTACHIAN TUBE.
From a woman, 29 years of age, who suffered several years ago from suppuration of the middle ear. Hearing-distance: acoumeter = 5 cm.; speech = 2½ m.

FIG. 214. — A SEPTUM BETWEEN THE EUSTACHIAN TUBE AND TYMPANIC CAVITY IS RUPTURED IN THREE PLACES.
After a preparation in my collection.

forward a little during the Valsalvan method, and shows a distinct movement during examination with Siegle's speculum.

Frequently, however, such cicatrices, probably in consequence of the repeated impact of the air upon them while blowing the nose, are ruptured in one or more places, the air then escaping freely into the meatus (Fig. 214).

When circumstances are favourable such perforated cicatrices can easily be diagnosticated if (Fig. 215), behind the anterior ledge-shaped remnant of the membrane in the anterior portion of the field of view, a black gap is visible, through which air or mucus-bubbles pass during the Valsalvan experiment. In a similar manner

the entrance to the mastoid antrum may be closed by a membranous septum, and by this means separated from the tympanic cavity.

In cases in which the whole inner surface of the membrana tympani is adherent to the promontorial wall the depressed or flattened membrane, thickened like parchment, appears pale yellow, opaque, and upon touching with a sound is rigid and inelastic. In other cases sharply defined, pit-like depressions (Fig. 216) are found, which have originated partly in retraction of the cicatricial tissue in some places, and partly in cord-like thickenings on the surface of the cicatrized membrana tympani. By such cords the handle of the malleus is drawn strongly backwards and inwards, and sometimes so tightly united to the incus and stapes that the vibrating power of the ossicula is thereby reduced to a minimum. The

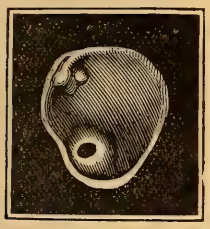

FIG. 215.—LARGE PERFORATION IN THE MEMBRANA TYMPANI.
The cicatrix, extending from the anterior remnant of the membrana tympani to the inner wall of the tympanic cavity, is perforated. From a woman, 48 years of age, who suffered for 28 years from discharge from the ear.

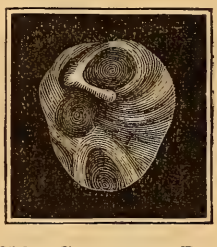

FIG. 216.—CICATRICIAL DEPRESSIONS AND CORD-SHAPED THICKENINGS ON THE MEMBRANA TYMPANI.
From a young man, 19 years of age, who suffered in childhood from otorrhœa. Hearing-distance for speech $= \frac{2}{3}$ m.

recognition of the formation of such cords is of great importance, for their division by operation is frequently followed by a striking improvement in the hearing.

After middle-ear suppuration the tympanic cavity itself may also be divided by pseudo-membranes, by adherent cicatrices of the membrana tympani, or by the direct formation from the remnant of the membrane into several irregular spaces, which either communicate with each other or are completely separated.

If, however, any of these cavities are so completely closed that no air can enter them, they gradually collapse or they are filled up with a mucous or purulent exudation, or are the seat of small cholesteatoma, which, if they are deposited within the field of view, may be observed as whitish prominences, from which after incision the epithelial masses can be removed.

Equally interesting and important are those diverticula in the

posterior superior portion of the tympanic cavity, which communicate only with a portion of its superior space or with the cells of the mastoid process, and are completely separated from the anterior portion. The portion of the membrana tympani situated behind the handle of the malleus is bulged forward without inflammatory symptoms in the form of a darkish-brown tumour (viscid mucus), or there may be seen (Fig. 218) a greenish globular bulging (pus) after the opening of which the secretion discharges freely. Such limited suppurations are exceedingly tedious, because the seat of the process cannot be made aseptic.

There yet remains to describe the suppurations confined to the posterior superior portion of the tympanic cavity, and usually ac-

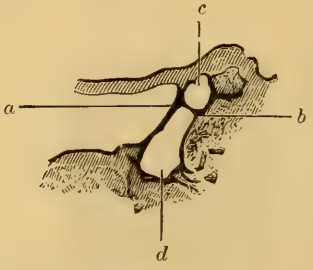

FIG. 217.—MEMBRANOUS BRIDGE FROM THE MEMBRANA TYMPANI.

a, To the inner wall of the tympanic cavity; *b*, Horizontal section through the left ear of a girl, who died of general paralysis, caused by a tumour of the brain, and who previously suffered from suppuration of the middle ear.

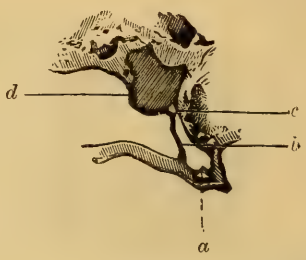

FIG. 218. — DIAGRAMMATIC SECTION THROUGH THE EXTERNAL MEATUS AND TYMPANIC CAVITY TO SHOW THE DIVERTICULUM, CONTAINING A DEPOSIT OF EXUDATION IN THE POSTERIOR SPACE OF THE TYMPANIC CAVITY.

a, Anterior portion of the tympanic cavity; *b*, Membrana tympani; *c*, Adherent handle of the malleus; *d*, Posterior portion of the membrana tympani, bulged forward by exudation.

companied by suppuration of the mastoid antrum. Here the septic secretion, generally crumbling, escapes into the external meatus through a small perforation in the posterior superior quadrant, but at the same time, through adhesion of the anterior remnant of the membrana tympani to the promontory, the anterior portion of the tympanic cavity is separated from the posterior secreting portion (Fig. 219). This suppuration is specially noticeable on account of its resistance to treatment. The same holds good of those cases in which the inferior half of the membrana tympani is destroyed, and the inferior margin of the superior half of the membrane is so adherent to the inner wall of the tympanic cavity (Fig. 220) that the superior space of the cavity is only in communication with the inferior portion by a small aperture, or is completely separated.

Connective-tissue Formation in the Tympanic Cavity.—Of greater importance as regards the disturbances of hearing remaining after middle-ear suppuration, are the connective-tissue formations accompanying the adhesive processes in the tympanic cavity. Most frequently one meets a mass of connective tissue, sometimes succulent, sometimes hard, completely surrounding the malleus and body of the incus in the upper tympanic cavity and in the mastoid antrum, together with the niches of the fenestræ ovalis and rotunda. Occasionally one finds atresia of the ost. tymp. tubæ from granulations or connective tissue. There may be, as in several preparations in my collection, complete filling of the cavum tympani, with newly-formed connective tissue, so that no trace of an air space can be found in it.

These new-formations of connective tissue, after they have existed

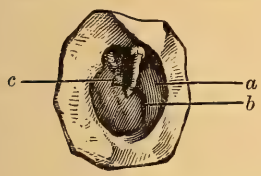

FIG. 219.—AN ADHERENT CICATRIX IN THE RIGHT MEMBRANA TYMPANI.
a, Anterior thickened remnant of the membrane; *b*, Cicatrix, extending from the margin of the remnant of the membrane to the promontory; *c*, Capitulum of the stapes, covered by cicatricial tissue; above it an opening extending into the upper space of the tympanic cavity.

FIG. 220.—VERTICAL SECTION THROUGH THE EXTERNAL MEATUS AND THE TYMPANIC CAVITY.
a, Free ledge-shaped remnant of the membrana tympani; *b*, Place of adhesion of the margin of the perforation.

for some time, may become ossified or calcified by a deposit of calcareous salts. In a case observed by me in which, after the subsidence of a chronic suppuration of the right ear deafness of high degree was developed, the post-mortem examination showed that the head of the malleus and the body of the incus were to a great extent enveloped in an osseous mass, firmly united with the upper and outer wall of the tympanic cavity, which no doubt had its origin in a proliferation of the mucous membrane. Besides, there may develop in the hypertrophied mucous membrane of the tympanic cavity, after the cessation of the suppuration, that condition previously described as sclerosis.

The presence of connective tissue or calcareous masses in the upper spaces of the tympanum as well as other products of middle-ear suppuration in the region of the hammer and incus can only be

inferred from the severe deafness accompanying the process. It is only in specially favourable cases, with a large meatus, a considerable distance between the remainder of the membrane and the promontory, that it is possible to see the upper and posterior portion of the tympanic cavity by using the small mirror proposed by Blake and Bing with an intense light and magnifying lens. R. Botey, who has given special attention to intra-tympanal otoscopy, describes

Fig. 221.

a series of interesting observations. With the small mirror (Fig. 221) sent me by Botey I could, within the last few years, often diagnose adhesions between the handle of the malleus and promontory, changes on the bodies of the malleus and incus, in the two fenestræ, on the posterior wall of the tympanic cavity, at the ost. tymp. tubæ, and in cholesteatomatous cavities of the temporal bone, which could not be seen by ordinary ocular inspection. A more complete illuminating apparatus than those we have at present may in the future further the diagnosis of hindrances to sound-conduction and their operative treatment.

Although it will be seen, from the above, that in many cases the diagnosis of the adhesive processes is rendered possible by a number of characteristic indications seen on examination with the speculum, it must on the other hand be pointed out, that the anatomical changes within the field of view are frequently so complicated, that to understand what is seen is very difficult, or even quite impossible. This refers especially to those cases in which the secretion still continues and the outlines of the different structures have become obscured and indistinct in consequence of tumefaction of the inflamed parts. In this way it happens, that in case of adhesive processes even the most experienced specialist is frequently able to make a precise diagnosis only after observing the changes which occur in the course of the disease. The deviations from the normal state which present themselves to the eye are of such variety, that only by an exact knowledge of the anatomical relations and by many years' practice are we enabled to understand the details correctly, and to form, in difficult cases, an opinion from what we have observed. The formation of a correct diagnosis in the adhesive processes is, however, not only of theoretical, but also, as we shall see, of practical value, inasmuch as by means of an operation based upon the diagnosis, a striking improvement in the hearing may be effected, where previously all other methods of treatment remained without result.

The deafness produced by adhesive processes in the middle ear varies according to the extent of the obstacles to the conduction of sound which have been set up in the ossicular chain and in the

fenestræ of the labyrinth. The degree of the disturbance of function is not always, however, in relation to the anatomical changes. The greatest degree of deafness is seen in fixation of the hammer and incus through masses of connective tissue in the attic, in connective tissue or calcareous fixation of the foot-plate or crura of the stapes, and lastly, in thickening of the membrane of the fenestra rotunda. If the adhesion is confined to the portion of the membrana tympani situated below the handle of the malleus, the acuteness of hearing, as I have repeatedly observed, may still be considerable. Adhesions in the upper part of the membrane, however, produce more frequently a considerable disturbance of hearing, especially when the handle of the malleus is drawn inwards by the adherent cicatrix so that it anchyloses with the promontory.

In the same way the adhesion of the cicatrized membrana tympani to the incus and stapes, as well as adhesions which unite the ossicula to each other, will produce deafness of different degrees according to the firmness and tightness of the new-formed ligaments. But when the articulation of the incus with the stapes has been destroyed by the purulent process, the adhesion of the membrana tympani or of the cicatrix to the stapes may be of advantage to the hearing, because in that case the sound is immediately transferred from the cicatrix to the stapes.

3. *Epidermization of the Edges with Persistence of Perforations in the Membrana Tympani.*

A permanent perforation in the membrana tympani, after chronic suppuration of the middle ear has ceased, chiefly takes place in the case of extensive losses of substance extending to the tendinous ring; but, frequently enough, small gaps are observed to remain permanently. The most frequent anatomical cause of persistent perforation of the membrana tympani, according to my observation, is the extension of the epidermis from the external surface of the membrane over the edge of perforation, thereby preventing the formation of a cicatrix.

But it is not every perforation which remains open for some time after the suppuration has ceased that may be considered as permanent, because occasionally, although not frequently, cases are observed in which the perforation cicatrizes several years after the suppuration has ceased. In a case, described by me, in which the membrana tympani was destroyed, with the exception of a narrow fragment at the periphery, complete regeneration of the membrane took place without adhesion to the inner wall of the tympanic cavity.

In the case of a permanent defect in the membrana tympani

(so-called dry perforation), the membrane does not always retain a constant appearance. Large apertures after some time often diminish to the size of a pin-hole; more frequently, however, an enlargement of the perforation is observed, especially after repeated relapses of the suppuration, but sometimes also without any recurrence of the secretion. Not unfrequently the defect alters its position completely. In a case in which a polypus of the tympanum projected through a perforation the size of a pea, I found six months after the removal of the polypus the membrana tympani dry, a large calcareous deposit in the former site of the perforation, and in the posterior superior quadrant of the membrane a round, black aperture the size of a pin's head. At subsequent examinations with the speculum not unfrequently calcareous spots, atrophied depressions and adhesions are found, of which no traces were observed in previous examinations.

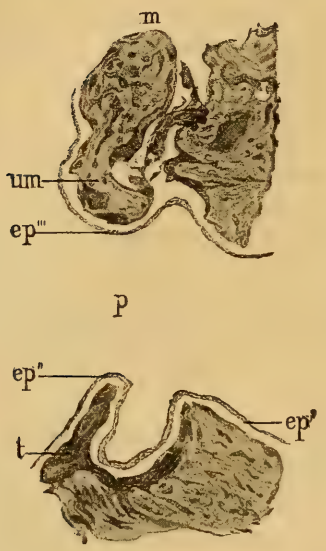

FIG. 222.—FRONTAL SECTION THROUGH THE MEATUS AND MEMBRANA TYMPANI AFTER A MIDDLE-EAR SUPPURATION, WITH PERSISTENT PERFORATION IN THE MEMBRANE.

m, Head of the hammer; *um*, Stump of the neck of the hammer; *t*, Lower part of remaining membrane; *p*, Perforation in the membrane; *ep*, Epidermis of osseous meatus; *ep'' ep'''*, External epidermis extending through the opening into the cavum tympani.

Concerning the disturbances of hearing in cases of permanent perforation, numerous observations have already proved that a fairly good hearing-power may still exist, even in cases of extensive destruction of the membrane. Indeed, even when the malleus and the incus were destroyed and exfoliated, or when the malleus was completely fixed by an almost total calcification of the remnant of the membrane (Fig. 223), whispered speech could be still understood at a great distance, provided the foot-plate of the stapes was movable, and the membrane of the fenestra rotunda was not thickened. In these cases hearing is affected by the waves of sound falling immediately upon the movable foot-plate of the stapes. In the case of permanent perforations it may, therefore, always be inferred from the existence of a good hearing-distance, that the mobility of the stapes has not been impaired by the purulent process. But in the case of

more considerable deafness, a material obstacle to the conduction of sound in the stapes or in the membrane of the fenestra rotunda must be assumed. The obstacles to the transmission of sound by the stapes are of various kinds. Most frequently it is tight, sclerosed, new-formed connective tissue at the niche of the fenestra ovalis which fixes the stapes. The latter may, however, also lose its power of vibration without any adhesion to the surrounding parts, in consequence of the malleus and the incus being drawn inwards by adhesions, by which the stapes is forced inwards and fixed, owing to the pressure exerted upon it by the long crus of the incus. This is certainly a frequent cause of great deafness in cases of permanent perforation, and its detection is therefore important; because, by removal of the pressure which rests upon the stapes, a striking improvement in the hearing may be effected.

That want of tension is also frequently the cause of great deafness in the case of permanent perforations of the membrana tympani is according to pathologico-anatomical examination without doubt.

In the so-called dry perforations the hearing-power is not subject to those great fluctuations observed in the secretory stage.

As a rule the deafness, after suppuration has ceased, does not exhibit that progressive character which is characteristic of the chronic adhesive processes, in which no suppuration takes place. Cases are not unfrequent in which, after suppuration has ceased, the deafness remains stationary for years, indeed even during a lifetime. Frequently enough, however, after suppuration has ceased, a progressive or fitful decrease in the hearing-power, ending even in total deafness, is observed, which is due partly to continually increasing rigidity of the new-formed connective tissue, and to anchylosis of the ossicula, and partly to secondary changes in the labyrinth, to which we will refer when discussing the diseases of the nervous apparatus.

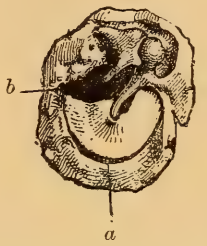

FIG. 223.—EXTENSIVE CALCIFICATION OF THE LEFT MEMBRANA TYMPANI, AFFECTING ALL ITS LAYERS.

a, The peripheral portion as well as a narrow strip in front of the handle of the malleus not calcified; *b*, Irregular defect in the posterior superior quadrant of the membrane. Membrana tympani and malleus rigid and immovable; continuity between incus and stapes destroyed; the latter, however, completely movable. (From a girl, 16 years of age, who died of pulmonary phthisis.) Similar changes also existed in the right ear. The patient could understand whispered speech in both ears from any part of a hospital ward 18 m. long.

4. *The Desquamative Processes and the Formation of Cholesteatoma in the Ear during Chronic Middle-ear Suppuration.*

In chronic middle-ear suppuration there occurs an excessive desquamation of epithelial cells in the external meatus and on the mucous membrane of the tympanic cavity during the secretive stage. In the secretion there is almost always, besides the pus cells, separate cells or collections of epithelium in varying degrees.

If the production of epithelium is not excessive and there is no hindrance to the discharge of the pus mixed with epithelium, the process may continue for years without the formation of an epithelial mass in the middle ear. On the other hand, if there is excessive desquamation of the proliferating epithelium, so that during the suppurative process it pushes from the external meatus through the perforation into the tympanic cavity, the epithelial mass forms into larger whitish or yellowish balls which collect in the cavum tymp. and in the external meatus. Besides the excessive epithelial desquamation the collection of epidermis flakes is favoured by the hindered flow of secretion. To the hindrances belong the following: the narrowing of the meatus, multiple formation of polypi, adhesions between the membrana tympani and the inner wall of the tympanic cavity, and the formation of sacculated spaces in the tympanic cavity. Crumbling epithelial lumps are seen in the secretion with small perforations in the posterior superior quadrant of the membrana tympani, and in Shrapnell's membrane.

The formation of such retention masses may go on for years without special symptoms. Occasionally there occurs a spontaneous casting-off of a large mass accompanied by severe pain. Very often there occurs after a long stagnation in the deeper portion a breaking down of the retention product, owing to the action of bacteria into dirty, ill-smelling detritus containing a large number of cocci, which often enough produces an ulcerative disease of the bone with a fatal result. These broken-down masses are often met with in the dissection of cases where death occurred from brain affection or sinus phlebitis due to caries and necrosis of the temporal bone.

Besides these formless masses which do not hang together and which extrude from the external meatus and the middle ear, there occurs, as well during the suppuration as after it ceases, the formation of limited masses, often covered with a pearly, glittering coat, consisting of a homogeneous mass or of concentric lamellæ which are similar in their appearance and structure to the cholesteatomata found in other organs. For these tumours as well as for those structureless lumps of epidermis, the term cholesteatoma of the ear is used.

Cholesteatomata in the ear have long been known to pathologists, as is shown by the communications of Cruveilhier, Rokitansky, Virchow, and others. As to the formation of these epidermis masses there are at present many diverging views, as Virchow, Mikulicz, and Küster consider that cholesteatoma in the temporal bone is of heteroplastic formation, v. Tröltsch as a retention tumour, Wendt as the production of a desquamation of the middle ear or mucous membrane, Bezold and Habermann as the production of epidermis growing from the external meatus into the tympanic cavity through the perforation in the membrana tympani.

The occurrence of primary cholesteatoma in the temporal bone must be considered very rare from a clinical standpoint in comparison with the secondary epidermis collections. The results of Virchow's investigation leaves us in doubt whether the heteroplastic tumours which are imbedded in the upper portion of the temporal bone broke through the walls of the tympanic cavity during their growth, or whether they caused the absorption of the bone in their growth from the middle ear. A rare case of cholesteatoma of the mucous membrane of the tympanic cavity, which occurred without a trace of suppurative inflammation and without perforation of the membrana tympani, is reported by Lucae. An interesting case of primary cholesteatoma is reported by Kuhn. This affected a man aged 51 years, who for a number of years had tinnitus in his left ear, attacks of giddiness and deafness, and after a severe cold a suppurative middle-ear inflammation developed with severe pain, and the formation of an abscess in the mastoid process. After opening the mastoid process there was found a cholesteatoma the size of a hen's egg, after the removal of which the sinus lateralis and a portion of the cerebellum with its covering were plainly visible, owing to destruction of the inner osseous wall.

In the category of primary cholesteatoma growing from the diseased mucous membrane may be reckoned those cases in which, during the course of a suppurative middle-ear inflammation, depressions lined with epithelium occur in the hypertrophic mucous membrane of the tympanic cavity. The openings of these secondary depressions close, and the epithelium within them develop cystoid spaces. In fact I found whitish, smooth epithelial balls, as large as the head of a pin, growing in the mucous membrane of the middle ear and completely embedded. This view is substantiated by the microscopical condition of the mucous membrane of the middle ear, described on page 356, in which the enclosed cyst contains a layer of cast-off epithelium. To this formation of cholesteatoma the preparation, shown in Fig. 226 has to be reckoned.

In the greater majority of cases the secondary growth of ear cholesteatoma is without doubt, as shown by clinical and pathological observation. Although it has been said that very often a secondary

cholesteatoma in the middle ear is due to the extension of the epidermis of the meatus into the tympanic cavity, yet according to my observation of a number of preparations in my collection, it is probable that the cholesteatoma may develop in the middle ear itself, and especially in the mastoid antrum and cells (Rohrer). From the frequent occurrence of laminated cells, without nuclei in these formations, it is probable that the mass developed in that position cannot be considered as coming from some other locality, as in the cases examined by me the epidermis cells from the external meatus contained nuclei.

The production of epidermal elements in the tympanic cavity and the mastoid process can only occur if the mucous membrane of the middle ear has undergone epidermic changes. Steinbrügge (in Moos's clinic) and Kuhn found the osseous wall of the cavity containing the cholesteatoma lined by a membrane which showed a clear Rete Malpighii, and was covered on its surface with laminated cells. This complete transformation of the middle-ear mucous membrane can be connected only with extensive changes in structure, and occurs as a fact during and after the course of suppuration which is accompanied by extensive infiltration with papillary hypertrophy or as the result of inflammatory connective tissue, thickening, condensation and atrophy.

The epidermization of the middle-ear mucous membrane occurs, according to my observation, after the continuity between the lining of the middle ear and meatus has been established through a perforation of the membrane, and the growth of the epidermis from the meatus with its Rete Malpighii has extended into the tympanic cavity. In support of this view is the fact that in the accessory cavities of the nose, for example in the antrum of Highmore and frontal sinus, the lining of which is nearly analogous to that of the tympanic cavity, and in which the same pathological changes occur (Zuckerkandl), it is only in very rare cases that cholesteatomata are met with.

The invasion of the epidermis of the meatus into the tympanic cavity does not directly produce the formation of cholesteatomous masses. This is proved by the observation first made by Schwartze, and which I have seen in a large number of preparations, of an epidermic cul-de-sac which extends from the external meatus into the tympanic cavity and mastoid antrum, and remains such throughout the whole life. That such extensions of the epidermis of the meatus without the formation of cholesteatoma occur oftener than is generally supposed, is proved by the fact that in many preparations of former middle-ear suppurations with extensive perforation of the

membrana tympani, in which macroscopically no trace of an epidermal layer was visible in the tympanic cavity; by the microscope it could be seen that the epidermis from the external meatus had extended over the inner wall of the tympanic cavity. The invasion of epidermis from the meatus into the tympanic cavity only produces the formation of secondary cholesteatoma, if an excessive growth of the epidermis in the external meatus occurs, to which a decided desquamation in the lining of the middle ear may be added.

Another factor by which the invasion of epidermis from the external meatus into the tympanic cavity is favoured is the membranous or osseous closure of the ost. tymp. tubæ, which occasionally occurs in middle-ear suppuration. As long as the tube remains open and the epithelium of the tympanic cavity is uninterruptedly connected with that of the tube and the naso-pharynx, the entrance of the epidermis from the external meatus is met by a marked resistance. If the connection is broken, through the closure of the tube, the weaker epithelium of the tympanic cavity loses its resistibility and the epidermis from the meatus enters so much more easily, as in such cases an epidermic change of the middle-ear mucous membrane follows.

The larger the defect in the membrana tympani so much easier will the epidermis from the meatus penetrate into the tympanic cavity. In central perforations the extension is more difficult than in peripheral perforations. This is shown by the frequent occurrence of invasion of cholesteatoma in small openings in the posterior superior quadrant of the membrana tympani or in perforations of Shrapnell's membrane (Morpurgo, Bezold).

In no form of perforation of the membrane could I follow the extension of the epidermis from the meatus in the living, so certainly as in the destruction of the membrana Shrapnelli. The invasion through the peripherally situated opening in the membrane in this region occurs more easily, as from the upper wall of the meatus extensive growth of the cutis and epidermis takes place in the direction of the membrana Shrapnelli to the membrana tympani. The growth of the epidermis is more extensive here than on the other walls of the meatus.

The method of invasion for cholesteatoma is not always through the perforated membrane. In a case described by me, of cholesteatoma in the mastoid process, the extension of the epidermis into the sacculated mastoid cells could be proved through a fistulous opening on the cortical portion of the mastoid process, and through a second fistulous opening on the posterior wall of the meatus.

The size of cholesteatomata vary from that of a hemp seed to a

walnut, and larger. Their form is oval or conforming to the shape of the middle ear, and the irregular cavity in the temporal bone produced by destruction and resorption. The surface is smooth or glandular, with club or nipple-shaped projections. Only in the cross-section it shows sometimes a lamellar appearance; sometimes it has the appearance of freshly-made milk-cheese, rarely with a caseated centre (v. Tröltsch). They consist of round or polygonal epithelial cells, often without nuclei, mixed with granules, fat globules, cholestearine crystals and bacteria. Rarely there occurs nucleated giant cells (Lucae). With and between the epithelial masses one finds occasionally caseated exudate or half-fluid masses

FIG. 224.—LARGE DEFECT IN THE TEMPORAL BONE FILLED WITH A LAMELLAR CHOLESTEATOMA.
Complete destruction of middle ear and labyrinth. *o*, Upper border of the cavity; *u*, Lower border of it; *h*, Posterior to the antrum mastoid; *os*, Anterior edge of the cavity extending to the ost. tymp. tubæ. (After a preparation in my collection.)

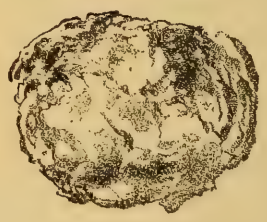

FIG. 225.—THE CHOLESTEATOMA REMOVED FROM THE CAVITY SHOWN IN PREVIOUS FIGURE.

of detritus. The most frequent position for cholesteatoma is the mastoid process, then the upper portion of the tympanic cavity and the external attic.

The cholesteatoma may reach a remarkable size without the occurrence of caries or disappearance of the bony structure of the temporal bone. Often, however, one finds, as well with small as with larger tumours, defects and excavations in the bone which is partially due to pressure and absorption, and partially to the atrophy of the bone-tissue connected with the pathological changes in the lining of the middle ear. There may occur cavities in the temporal bone due to carious destruction or exfoliation of necrotic portions of

bone, which may be further enlarged by the growth of the cholesteatoma.

The defects which are most frequently seen with it are the destruction of the margo tympani of the temporal bone, a larger portion of the posterior and superior bony wall of the meatus, and the mastoid process.

By this means there often occurs the formation of an extensive cavity in the temporal bone through the connection of the cavum tympani, the external meatus, and the mastoid process in one irregular cavity. Occasionally a portion of the pyramid is also involved in the destructive process.

A marked example of this is seen in the following case described by me. The woman, aged seventy-eight years, had suffered since childhood from

FIG. 226.—BEAN-SHAPED CHOLESTEATOMA IN THE TYMPANIC CAVITY. VIEW ABOVE AFTER REMOVAL OF THE TEGMEN TYMPANI.

v, Anterior end situated against the ost. tubæ ; *h*, Posterior end extending into the antrum ; *a*, Mastoid antrum filled with decomposed pus ; *s*, Sigmoid sinus ; *i*, Internal meatus. (After a preparation in my collection.)

complete deafness and facial paralysis on the right side due to otorrhœa. In Weber's test the tuning-fork was only perceived in the left ear. Dissection showed the following appearance. Behind the cartilaginous meatus there was a brown stratified mass, which on closer examination proved to be a tumour consisting of epidermis plates, lying one within the other (Fig. 225).

After the removal of this from the temporal bone a large opening was visible which extended from the ost. tymp. tubæ to the mastoid antrum on one side, and from the tegmen tymp. to the floor of the tympanic cavity and of the mastoid process on the other side. This cavity was lined with smooth connective tissue covered with shining epidermis. The external meatus, tympanic cavity, and mastoid process were transformed into one cavity ; of the whole labyrinth, vestibule, and facial canals there was only the thin upper and posterior wall of the pyramid remaining (Fig. 224).

Symptoms.—The cholesteatomous collections in the temporal bone may remain for years without symptoms. Often they produce without inflammatory symptoms a feeling of heaviness and pressure in that side of the head, headache, and dizziness. Through the occurrence of some external influence, however, for example, the penetration of fluid into the meatus, or after the effect of the steam in a Turkish bath (Moos), inflammation in the deeper parts of the temporal bone may occur, with severe reactionary symptoms, due to the rapid swelling of the epidermis mass. This may proceed to the spontaneous expulsion of the cholesteatoma through the opening in the membrana tympani, or to the penetration in different directions through the temporal bone. The inflammation in the attic and mastoid process produced by a cholesteatoma is often accompanied by sinking of the posterior superior wall of the meatus.

Results.—1. Healing after expulsion of the mass. This expulsion may result from rapid swelling of the mass and pressure of the fluid secretion behind it, forcing it through the perforated membrana tympani into the external meatus, or more rarely through the tube into the naso-pharynx. Besides this the cholesteatoma may break through the external shell of the mastoid process, with symptoms of abscess, and find a way out on the mastoid process (Steinbrügge); or it may penetrate from the mastoid process through the posterior wall of the meatus into the external meatus (Bezold, Schwartze, Moos, Politzer).

2. Fatal result. (*a*) Through pyæmia following septic regurgitation of the secretion behind the cholesteatomous mass. This result may follow without a trace of a carious affection in the temporal bone, as I observed in the following case:

A woman, aged 32 years, came to my clinic in December, 1884, with pyæmic symptoms and rapid failure of strength. She had suffered since childhood from a discharge from the left ear, and fourteen days previously was taken with fever and headache. There was a defect on the lower half of the membrana tympani, secretion slight, easily heard perforation-sound upon auscultation, severe deafness, and negative Rinne. By injecting fluid through the middle ear from the tube only a few drops entered the meatus. Repeated chills, pain in the course of the left jugular vein, hæmoptysis, œdema of the lungs, and death on the fifth day after examination. The necroscopy showed perforation of the membrana tympani with polypi on the lower portion of the promontory. The upper and middle tympanic cavity (Fig. 226) was filled with a smooth, shining white, bean-shaped cholesteatoma, the anterior rounded end of which reached to the region of the ost. tymp., while the posterior rounded end extended into the mastoid antrum and closed the opening of the antrum completely. As a result of the retention of secretion in the mastoid antrum the sigmoid sinus was inflamed, dark-red, although not carious. Sinus phlebitis, Thrombosis.

(*b*) Death from meningitis, abscess of the brain, erosion of the tranverse sinus with otorrhagia and sinus phlebitis (Rokitansky, Moos, Schwartze, Hessler, Bezold, Fischer), either following retention of secretion or with caries and necrosis of the temporal bone, accompanying the formation of the cholesteatoma, or through immediate perforation of the cholesteatoma on the tegmen tympani and mastoid, or on the posterior pyramidal wall towards the cranial cavity (Toynbee and v. Tröltsch). In a case by Burckhardt-Merian the penetration of the cholesteatoma not only occurred on the tegmen tymp., but also below through the incisura mastoid., by which means an abscess nearly the size of a fist resulted on the side of the neck.

Diagnosis.—The diagnosis of the desquamation process in the ear is of therapeutical importance, as apart from their destructive character, the middle-ear suppurations cannot be made to cease before this mass is removed from the ear.

The diagnosis of cholesteatomous collections in the middle ear can only be made with certainty if either the whitish or whitish-yellow occasionally glancing epidermis mass lie in the field of view, which occurs when the mass extends into the external meatus, or fills the opening in the membrane from the lower portion of the tympanic cavity. Where epidermis masses are seen in the upper portion of the field of view extending from the upper part of the tympanic cavity, one should think at once of cholesteatoma formations. An excessively developed epidermis in the external meatus, which may be followed by inspection into the tympanic cavity, makes the diagnosis probable. In a similar way a cholesteatoma in Prussak's space may be diagnosed from the whitish, doughy-feeling mass in the perforated membrana Shrapnelli. Important symptoms of the presence of caseated or cholesteatomous masses in the middle ear are the frequent appearances of gritty masses or of larger whitish-yellow strings in the water used for washing out the ear, which, when rubbed between the fingers, give a bad smell, and under the microscope show the character of degenerated pus, containing vibriones and lumps of laminated epithelium infiltrated by cocci. The diagnosis is more probably if these characteristic lumps are still seen after cleaning the ear for several days. This peculiarity of the secretion I have found generally in long-continued, obstinate suppuration, which is not profuse, in perforation of Shrapnell's membrane, farther in adhesion between the membrana tympani and the wall of the promontory, where the secretion can only escape through a small opening in the posterior superior quadrant of the membrane, and in protracted suppuration in the mastoid antrum, with fistulous opening in the osseous meatus. A similar secretion

occurs in chronic middle-ear inflammation, in scrofulous and tuberculous individuals and those affected with ozæna.

On the other hand, in cholesteatomata embedded in the mastoid process, or in the upper part of the tympanic cavity covered with a delicate shell, the diagnosis is impossible. For the diagnosis of their presence in the deeper portions, during the examination of the patient it is necessary that the tumour should break down, which is generally followed by the ejection through the opening of the perforation, or the penetration of the mass through the cortical portion of the mastoid process, or into the external meatus. Where the presence of desquamation in the middle ear occurs, especially with protracted casting off of these granular lumps, which have been formerly described, with frequent recurrent pain in the mastoid process, one may with probability conclude as to the presence of cholesteatoma in the mastoid process. This is an important indication for the operative opening of the mastoid process.

Prognosis.—The prognosis of cholesteatomata of the ear depends upon their situation, their extent, and upon the recurring changes in the ear; cases of complete healing after spontaneous ejection or after operative removal of the mass are on the whole rare. In general, the frequent recurrence of cholesteatomata in the middle ear should be considered a serious condition in middle-ear suppuration. During the suppuration the hindered flow of secretion, and after it stops the persistent desquamation in the external and middle ear and the extension of the epithelial growth to the osseous cavities and the walls of the tympanic cavity (Kirchner), should be considered as the cause of its recurrence. While in certain cases the epidermis invasion into the tympanic cavity proceeds often to the formation of culs-de-sac, which may persist without further trouble; in other cases it may proceed to the new formation of cholesteatomous masses, by which the cavities in the temporal bone may be filled within a short time.

The formation of crusts in the outer and middle ears should also be mentioned here. These arise from the drying up of the secretion not removed in cases of scanty exudation. The brownish-green crusts generally lodge in the inner section of the osseous meatus, and frequently extend over the remnant of the membrana tympani, through the opening of the perforation and into the tympanum. They often adhere so firmly to the subjacent tissue, that they can with difficulty be removed by a blunt probe. Sometimes the cure of the suppuration in the middle ear is quite prevented by the formation of a crust which adheres firmly for a long time. But often enough in cases in which the suppuration has long been believed to be arrested, it is found to be still going on beneath the crust. On the removal of the latter the under-

lying surface is seen covered with a layer of thick pus, and sometimes even studded with granulations of considerable size. Sometimes small perforations are blocked by a crust, as by a plug, and the closure of the gap is thereby hindered. Crusts should therefore always be removed (see Treatment).

We sometimes observe small, dry, firmly-adherent crusts in the bases of depressed, adherent cicatrices of the membrana tympani. They are most frequent in the base of cicatrized perforations of Shrapnell's membrane, and next most common in cicatrices in the posterior superior quadrant of the membrana tympani, which have adhered to the articulation of the incus with the stapes, or to the head of the stapes separated from the incus. The diagnosis of a crust in this situation is therefore important, because, as I have several times observed, by the careful removal of quite small crusts from this region, a surprising improvement in the hearing is produced.

Prognosis of Chronic Middle-ear Suppuration.—The prognosis of chronic suppuration of the middle ear is generally uncertain, for as long as the suppurative process continues, we can never foretell with certainty what course it will take (Wilde). But the cause of the onset of the suppuration, the local changes present in the middle ear, and especially the state of the general health at the time, frequently offer important grounds for the determination of the prognosis.

The prognosis of the suppurative processes is favourable when the disease is idiopathic, and the individuals strong and healthy. A more favourable course may generally be expected in those cases in which the secretion is slight, or where there exists a possibility of the resolution of the morbid changes in the middle ear; also when the defects in the membrana tympani are not extensive, when the mucous membrane of the middle ear is smooth, not granular, and the Eustachian tube is patent.

But a less favourable prognosis must be formed in the middle-ear suppuration following scarlatina, measles, influenza, typhus, scrofula, syphilis, diabetes, leucocythæmia, and other cachexias, as well as with chronic naso-pharyngeal catarrh and ozæna. Unfavourable prognostic local changes are: profuse blennorrhœa or persistent septic secretion containing streptococci, large perforations in the membrana tympani, perforation of Shrapnell's membrane (Bezold), excessive proliferation of the mucous membrane of the tympanum, or extensive formation of granulations on the same; also when there is polypoid degeneration of the membrana tympani, ulceration of the lining membrane and of the osseous walls of the middle ear, tight stricture of the Eustachian tube, formation of cholesteatoma in the middle ear, paresis and paralysis of the facial nerve, or those secondary changes in the external meatus,

accompanied with bulging in the upper wall of the meatus, with which we shall become acquainted in the description of the carious processes.

The prognosis for the hearing is hardly determinable in the suppurative stage, for this is not always conditioned by permanent obstacles to the conduction of sound, but by simple swelling of the mucous membrane enveloping the ossicula, which may be almost entirely resolved on the cessation of suppuration. One is generally justified, however, in forming a more favourable prognosis in those cases in which the hearing-disturbance is not of a high degree, or in which, after the injection of air into the middle ear, and after the removal of the secretion, a striking improvement in the hearing takes place, than in those in which the greatly-impaired function only undergoes a slight improvement from the dilatation of the Eustachian tube, and in the course of treatment. Exfoliation of the ossicula, as well as tight stricture of the meatus tending to complete obliteration and adhesions of the ost. tymp. tubæ, render the prognosis still less favourable.

On the cessation of the otorrhœa the prognosis regarding the function of hearing is most favourable in those cases in which the orifice of the perforation cicatrizes, and only a slight disturbance of the hearing remains. But it is unfavourable if after the closure of the perforation a striking decrease in the hearing takes place, for this signifies a more serious obstacle to the conduction of sound at the malleus or incus.

In cases of persistent perforation of the membrana tympani the prognosis is more favourable when, in spite of the long continuance of the affection, the hearing-distance remains stationary; unfavourable if after the cessation of suppuration great deafness remains, and no change is experienced either from the dilatation of the Eustachian tube or the application of an artificial membrana tympani. And the prognosis is bad when the hearing-disturbance continues progressive, and when it is associated with continual subjective noises, and a diminution of the perception of sound through the cranial bones for the tuning-fork (Schwabach).

The Peculiarities of Suppurative Middle-ear Inflammation occurring with Infectious Diseases.

The course and result of otitis media purulenta, occurring with infectious diseases, show many variations from the genuine form, and, therefore, it appears important, from a practical standpoint, to consider the peculiarities of these forms of middle-ear suppuration.

Purulent Middle-ear Inflammation occurring with Typhoid Fever. —The slighter forms of middle-ear catarrh, without perforation of the membrana tympani, with serous or muco-purulent secretion in the middle ear, are quite common. They usually disappear after the course of the disease is over, or form the foundation for later adhesive processes. During the course of the disease they are generally kept in the background, and are first noticed at the beginning of convalescence. The severe deafness which is present in middle-ear catarrh during typhoid is undoubtedly due to the accompanying changes in the labyrinth, or to the action of the typhoid processes upon the centre of hearing.

Purulent middle-ear inflammation occurring with typhoid is less frequent, and was observed by Hoffmann in 250 cases of typhus four times, and by Bezold in 1,243 cases forty-one times. As the causes of middle-ear inflammation with typhoid, which usually occurs during the fourth or fifth week of the disease, are: the direct transmission of the inflammation from the naso-pharynx, so common in typhoid, either simple or diphtheritic, to the Eustachian tube and middle ear; the entrance of septic secretion from the naso-pharynx into the middle ear; the occurrence of embolisms in the mucous membrane of the middle ear (Bezold), resulting either from an endocarditis or from collections of pus in the periphery. The perforation which generally occurs in the posterior portion of the membrana tympani, and with slight reactionary symptoms, is usually larger than in the genuine middle-ear suppuration, but seldom exceeds the size of a lentil (Bezold). Hoffmann saw in acute cases two or more perforations.

The disturbance of hearing which accompanies the suppurative process is often of a high degree, especially when the ear affection occurs early, on account of accompanying peripheral or central disease of the auditory nerve. In convalescence the hearing-distance generally increases, although frequently severe deafness continues for a long time. The duration of suppuration is generally more protracted than in the genuine form, but usually ends, however, in otherwise healthy individuals with cicatrization of the opening in the membrane, and complete restitution of the function of hearing. The prognosis of middle-ear suppuration occurring in typhoid is therefore relatively good, as compared with that occurring with other infectious diseases;* yet severe forms also occur with inflammation and formation of abscesses in the mastoid cells, with caries

* E. Fränkel and Simmonds (*Deutsche med. Wochenschr.*, 1887) found in the secretion of middle-ear suppuration during typhoid only pus microbes, but no typhoid bacilli.

and necrosis of the temporal bone, facial paralysis (Hoffmann), extension of the frequently septic suppuration to the neighbouring organs, and complete deafness through panotitis. Even severe complications may end with complete healing. In a case observed in my clinic of profuse middle-ear suppuration after typhoid, with a high degree of deafness and the formation of abscesses in both mastoid processes, after opening the abscesses and the removal of several bony sequestræ from the mastoid, cicatrization of the perforation in the membrana tympani, with complete healing, resulted. A fatal result may occur from meningitis owing to caries of the tegmen tympani, through suppurative sinus phlebitis, or, as in a case reported by Bezold, through the embolic infarct owing to embolism of the posterior auricular artery. In a case reported by Hoffmann, the fatal meningitis followed suppurative middle-ear inflammation without perforation of the membrana tympani. In order to prevent the occurrence of middle-ear inflammation in typhoid cases, Bezold proposes, as a prophylactic measure, the removal of the stagnant secretion from the naso-pharynx by means of a sponge dipped in an antiseptic solution, after which the whole surface is made aseptic by blowing in boric acid. It is evident that this manipulation should only be carried out in those patients whose condition permits of it. The elimination of septic secretion from the naso-pharynx is also advisable as a prophylactic means in other infectious diseases. I do this also in the cases of simple typhoid catarrh, before the use of the air-douche, in order to prevent the penetration of secretion from the tube into the tympanic cavity.

The treatment of typhoid middle-ear suppuration in acute cases is antiseptic, and does not differ from that of the genuine middle-ear suppuration.

Suppurative Middle-ear Inflammation with Influenza. — The peculiarities of influenza otitis have already been mentioned with otitis media acuta, and acute suppurative middle-ear inflammation, for which reason I will only give a *résumé* of the clinical appearances and results of influenza otitis.

The appearance of this form of suppurative middle-ear inflammation takes place with severe reactionary symptoms, and is generally accompanied at the beginning by a hæmorrhagic inflammation of the membrana tympani with the formation of smaller or larger dark-blue or black bullæ in the lower posterior segment of the membrana tympani, which, after a short time, before perforation of the membrana tympani occurs, collapse, and discharge a bloody, serous fluid into the external meatus. In several cases there occurred simultaneously a formation of hæmorrhagic bullæ in the osseous

and cartilaginous meatus. The perforation usually occurs in front of the handle of the malleus, but very often it is in the posterior superior quadrant at the top of a round projection on the membrana tympani, at the highest point of which a drop of pus may be forced out by Valsalva's method. The pain, which is severe before the perforation, often remains for days without being alleviated. In some cases, even after the suppuration ceases, neuralgic pain with the character of otalgia remains. Subjective noises, such as pounding, hammering, and roaring, are always intense, and remain for a long time after the inflammation has stopped. The disturbance of hearing is usually more in the stage of suppuration than in the genuine middle-ear inflammation, and deafness of different degrees remains in a number of cases after the suppuration ceases. The suppuration is generally more protracted than in the genuine form. Very much more frequently than in the genuine form of inflammation an accompanying sinking of the posterior superior wall of the meatus occurs with severe reactionary symptoms, and with the formation of an abscess in the mastoid process. Spontaneous resorption of an abscess in the mastoid process was more rarely observed than in the genuine form; on the other hand, the production of caries of the osseous tissue was often very rapid, so that the opening of the mastoid process was necessary in order to prevent dangerous complications. Fatal results followed several times through meningitis, abscess of the brain, and sinus phlebitis.

Scarlatino-Diphtheritic Middle-ear Suppuration.—In the course of scarlatina, more frequently, however, when accompanied by naso-pharyngeal diphtheria, there often occurs the severest forms of acute purulent middle-ear inflammation.

The scarlatino-diphtheritic middle-ear suppuration develops generally at the height of naso-pharyngeal diphtheria, only seldom during its decrease. The inflammation begins with very severe pain, which, after the rapidly occurring perforation of the membrana tympani, usually remains for days. A painless course is rare. The temperature, which is increased by the naso-pharyngeal diphtheria, may upon the beginning of middle-ear suppuration be further increased (39° to 40°), and in children benumbed sensibility, delirium and convulsions may be added to the already existing head symptoms.

In no other form of middle-ear suppuration does so rapid destruction of the tissue of the membrana tympani with extensive perforation occur as in this. The extensive destruction of the membrane is not, as Schwartze believed, the result of the inflammatory swelling of the membrane, producing difficulty in the removal of the diphtheritic membrane from the tympanic cavity, but is un-

doubtedly due to the action of the specific cause of the disease (Streptococcus pyogenes),* which produces the rapid destruction of the tissue. Moos found, besides the excessive cell infiltration of the mucous membrane, necrosis of the epithelium and necrotic destruction of the bloodvessels.

If the case comes under observation soon after the perforation of the membrana tympani, it is often possible to see the diphtheritic membrane extending into the meatus. This is very difficult to remove by syringing as well as by mechanical means. In the latter manipulation the portion lying beneath it bleeds slightly. The condition is so characteristic that after some experience the diagnosis of otitis media diphth.-scarlatinosa is without difficulty, especially when the condition of the pharynx is taken into consideration. The mistaking of diphtheritic membrane for macerated epidermis plates of the external meatus is only possible in a superficial examination, as the appearance of the microscopical conditions are very different.

In the first days following perforation the secretion is generally slight (Wreden); after the casting off of the diphtheritic membrane it is very copious, often ill-smelling, bloody, or of a bad colour. The examination of the membrana tympani shows a large perforation which comprises two-thirds or nearly the whole membrane, and even when the disease has existed only a few days a bare livid-red, swollen mucous membrane of the inner wall of the tympanic cavity; the free handle of the hammer and the articulation of the stapes and incus are visible.

The suppuration in this form of inflammation always takes a protracted course; even under favourable conditions the secretion exists for two or three months. The most favourable course of the suppuration is produced when the physician is able to incise the membrana tympani within the first twenty-four hours (Moos). The restitution to the normal is rare; in most cases large persistent perforations of the membrana tympani remain. Often the suppuration becomes chronic, with the formation of granulations and polypi in the tympanic cavity on the remainder of the membrane and in the external meatus.

The disturbance of hearing in the acute stage is generally severe, but during the course of the disease it decreases, although in a

* According to the latest investigations, an inflammation of the mucous membrane can only be considered diphtheritic when Löffler's diphtheria bacillus is present. The presence of micrococci is to be considered as a secondary infection. The latter are present, however, in the necrotic membranous inflammation characteristic of scarlatina. So that scarlatino-diphtheritic disease of the ear must now be differentiated etiologically and pathologically from the true diphtheritic inflammation of the ear (Cozzolino, Babes).

large percentage of the cases severe deafness or even total deafness remains owing to the invasion of micro-organisms into the labyrinth, which in children during the first few years of life is the source of their becoming dumb as well as deaf. That, however, even in severe cases, the hearing function may be only slightly affected is proved by several cases in which after the expiration of middle-ear diphtheria, in spite of extensive defects in the membrana tympani, a hearing-distance of over six meters for whispering remained. The paralysis of the palate which remains after pharyngeal diphtheria leads to hindered ventilation of the middle ear with protracted hyperæmia and catarrh.

The scarlatino-diphtheritic middle-ear suppuration often leaves deeply-seated changes in the ear. The destructive process affects not only the membrana tympani, but also the bands of the ossicula, which are loosened and cast off. In a boy observed by me, who was entirely deaf after scarlatino-diphtheria, all the ossicula were destroyed on both sides. Often it extends to ulceration of the osseous walls of the middle ear to caries and necrosis of the temporal bone with exfoliation of smaller or larger portions of it, to erosion of the Fallopian canal with facial paralysis or to penetration into the cranial cavity with fatal result from sinus phlebitis, meningitis, or abscess of the brain. Kirchner observed anatomically, in a case of primary pharyngeal diphtheria extending to the tympanic cavity, an infiltration of the sheath of the chorda tympani nerve.

The *prognosis* of simple scarlatinous middle-ear suppuration is, apart from some severe forms, good in so far that after the cessation of the suppuration often complete healing and restitution of the hearing occurs. On the other hand, the prognosis of the scarlatino-diphtheritic form is less favourable when considering the accompanying complications. With regard to the treatment of scarlatino-diphtheritic middle-ear suppuration it must be observed that although in many cases, in spite of the most careful treatment, severe complications could not be avoided, yet in many cases by the institution of proper treatment the occurrence of that severe degree of deafness is prevented, which is so often seen when the suppurative process is left alone.

The *treatment* of diphtheritic or scarlatino-diphtheritic middle-ear inflammation must be immediately instituted after the perforation of the membrana tympani in order to prevent the destructive influence of the diphtheritic exudate upon the tissues. When perforation has not occurred, paracentesis should be performed at once. The treatment of diphtheritic middle-ear inflammation is strongly antiseptic, and one should be careful to have the ear

syringed out several times a day with lime water or with a 1 in 1,000 solution of sublimate. As regards the other details, refer to page 183. In bilateral ear disease complicated by naso-pharyngeal diphtheria, the middle ear should be washed out daily with a boric acid solution by means of Weber's or Saemann's douche in order to remove septic secretion and cast off diphtheritic membrane from the middle ear. On the other hand, in naso-pharyngeal diphtheria without ear affection, syringing in the nose should be done with great caution, as by severe pressure the penetration of the fluid into the tube may easily produce a diphtheritic process in the middle ear. The local treatment of the ear must always be combined with the antiseptic

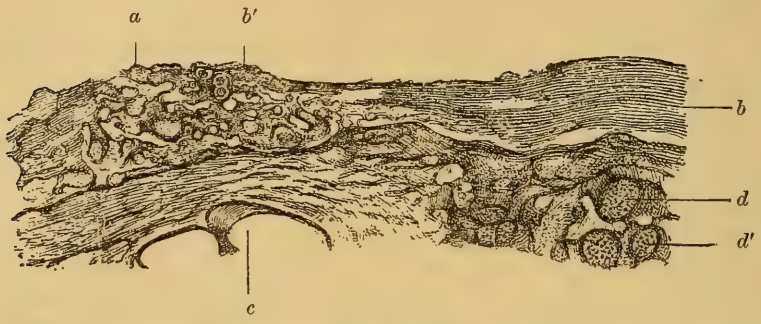

FIG. 227.—MICROSCOPIC SECTION OF THE INNER WALL OF THE TYMPANIC CAVITY OF A WOMAN, 36 YEARS OF AGE, WHO DIED OF PULMONARY PHTHISIS, AND WHO HAD SUFFERED FOR FOUR MONTHS FROM PROFUSE SUPPURATION OF THE MIDDLE EAR ON THE RIGHT SIDE.

The anterior portion of the inner wall of the tympanum is completely deprived of its mucous membrane, and the exposed bone is pale, somewhat rough and uneven. In the section the boundary of the mucous membrane (*b b'*), which becomes thinner towards the place where the loss of substance has occurred (*a*), can be distinguished. The bare bone (*a*), the structure of which is sharply set off from the capsule of the cochlea (*c*), lying below it, presents everywhere the characters of inflammation. The remains of the corroded osseous lamella (*a*) project on the surface like small ridges. The vascular spaces, as also the larger osseous spaces (*d d'*), in the posterior portion of the petrous bone, are filled with granulation cells.

treatment of the naso-pharyngeal affection in the form of atomized solutions of boric acid or resorcin.

Suppurative Middle-ear Inflammation with Tuberculosis.—The occurrence of suppurative middle-ear processes in tuberculous individuals, especially with lung affections, was known to the older authors, and even Romberg, Grisolle, Nelaton, Rilliet, and Barthez made observations as to the connection of middle-ear process with the tuberculous dyscrasia. More recently tuberculosis of the ear has received greater attention. In my *Beleuchtungsbildern des Trommelfells* (1865, page 65) I mentioned the clinical peculiarities of phthisical middle-ear suppuration. The valuable anatomical and clinical observations of tubercular middle-ear suppuration which we owe to Virchow, Toynbee, Zaufal, v. Tröltsch, Schwartze, and others, are, however, only few in number. Only since the discovery of the

tubercle bacillus by Koch has the pathology of this form of disease received marked advancement.

The pathological changes of the mucous membrane of the middle ear in tuberculous inflammation, in spite of the numerous clinical observations, are, on the whole, little known. Tuberculous caseated infiltration of the mucous membrane (Schwartze) is seldom observed; more common, however, is the presence of tubercular nodules on the membrana tympani, which by rapidly breaking down produce destruction of the tissue of the membrane and suppuration. The histological knowledge of the tuberculous nature of this condition is wanting. What changes occur in the mucous membrane of phthisical individuals is shown by the condition reported by me (*Lehrb. der Ohrenh.*, first edition, page 467, 1882), in which (Fig. 227) a portion of the mucous membrane of the promontory was destroyed by the tuberculous process. Since that time I have observed a number of mastoid bones from phthisical individuals with suppurative otitis media, and have repeatedly found such extensive destruction of the mucous membrane that the walls of the tympanic cavity and mastoid process were as destitute of mucous membrane as in a macerated bone. At the same time the membrana tympani was completely destroyed and the ossicula were loosened, owing to destruction of the bands; they were without covering of the mucous membrane, and in one case the hammer and incus were lacking. Habermann, who examined twenty-one ears of tuberculous patients histologically, could only distinguish the tuberculous nature of the ear affection in five cases. In these the mucous membrane of the middle ear was swollen, with occasional groups of giant cells containing tubercle bacilli. In one case I found on the lower circle of the cochlea granulations containing giant cells and bacilli, and in the facial nerve tuberculous nodules with bacilli. Lucien Piqué reported a case of tuberculous ostitis of the temporal bone in a scrofulous individual which was complicated with vascular keratitis, amblyopia, anæsthesia of the face in the region of the trigeminus, and facial paralysis. The occurrence of complete deafness happened only a few days before death from otorrhœa. Observations at the dissection: pachymeningitis above the petrous portion of the temporal bone and tuberculous neoplasms in the Gasserian ganglion.

The suppurative middle-ear inflammation develops in every stage of lung tuberculosis or with tuberculosis in other organs, most frequently with existing phthisis. It occurs frequently without reactionary symptoms, and rarely is preceded by slight twinges or severe pain. In the majority of cases its presence is known by the subjective disturbances of hearing and a slight discharge. Often, according to my observation, the suppurative process commences in the last days of life. The examination shows in recent cases a pale membrana tympani covered with a creamy secretion softened and perforated in the central portion, or, as in one of my cases, in the extreme periphery. Blake and A. H. Buck (*New York Med. Journal*, 1886) consider the painless occurrence of infiltration and destruction of the posterior superior quadrant of the membrana

tympani as the characteristic symptoms of beginning middle-ear tuberculosis. Chronic cases, according to my experience, usually occur without reactionary symptoms. In some cases, however, which are complicated with extensive affection of the bone, there is severe pain, a profuse secretion with rapid complete destruction of the membrana tympani and partial or extensive destruction of the mucous membrane of the tympanic cavity with deeply seated caries of the bone, affecting the Fallopian canal and facial nerve, the labyrinth, and even extending to the cranial cavity; further, caries, necrosis, and exfoliation of the ossicula occur, with carious, necrotic inflammation of the mastoid process and acute formation of sequestra with perforation in that region. By extension of the process to the labyrinth, purulent inflammation, thickening and partial destruction of the membranous structure occur; farther, cell proliferation and new connective-tissue formation on the wall of the labyrinth and in the semicircular canals. The carious destruction may, as I have several times seen, be combined with osteoporosis and hyperostotic new-formation of bone in the region of the carious spots.

Not every middle-ear suppuration occurring with tuberculosis can be considered as a tubercular process in the middle ear. We are only justified in concluding as to the tubercular nature of the middle-ear affection if the purulent inflammation is accompanied by a rapid destruction of the tissue of the membrana tympani, and a destruction of the mucous membrane of the tympanic cavity laying bare the promontorial wall which can be proved by inspection and careful sounding, and lastly, if tubercle bacilli can be found in the discharge.

The failure of the latter is no proof that it is not a tuberculous process, as, according to Habermann, in undoubted tuberculosis of the ear no bacilli were found. Nathan always found tubercle bacilli in the otorrhœal discharges of phthisical individuals, also in several cases of caries of the ossicula, and in the pars mastoidea. The severe painful complications are produced by the action of streptococci, and in such cases tubercle bacilli will be very few or not present in the discharge (Moos).

In either case where there is a suspicion of tuberculous middle-ear suppuration, it is very important from a prognostic view to examine the secretion for tubercle bacilli, although a negative result does not preclude the tuberculous nature of the ear affection, and the presence of bacilli does not certainly prove a tuberculous affection. Yet the presence of bacilli in the secretion must generally be considered an unfavourable prognostic sign.

The prognosis of otorrhœa in tuberculosis is generally unfavourable, yet in individuals in whom no phthisical affection of the lung was

present after careful antiseptic treatment (antiseptic syringing, insufflation of iodol powder), and living in a southern climate during the winter, healing has often been observed. In phthisical individuals, however, especially if the presence of the tubercle bacilli in the pus, and a destruction of the mucous membrane of the middle ear is proved, the prognosis is absolutely unfavourable. The healing of the suppuration, as observed by Orne Green and the author in two cases, occurs very rarely. The subcutaneous injection of Koch's lymph (Tuberculin), which has been tried on different sides, has proved therapeutically worthless, in spite of occasional severe reactions of the tuberculously-diseased ear in the form of increased swelling of the mucous membrane of the middle ear and profuse suppuration.

Middle-ear Suppuration following Syphilis.—The occurrence of purulent middle-ear inflammation following syphilis was known to the older ear specialists, and Itard (*Maladies de l'Audition*, 1821) described many forms which have been observed during the last ten years by Wreden, Roosa, Gottstein, Baratoux, Buck, Pomeroy, the author, and others. In most cases the middle-ear suppuration extends from syphilitic, naso-pharyngeal affections, but it may occur as a primary affection produced by catheterization at the mouth of the tube. The presence of such primary chancroid ulcers at the ost. pharyng. tubæ is proved by the observation of Ricord, Lancereaux, Blanchet, Fournier, Bouquoy, Laboulbène, Baratoux, and others. Often the syphilitic ulcer or condyloma of the naso-pharynx extends to the tube, with symptoms of the closure of the tube, resulting in stricture of it, or the inflammation may extend to the middle ear, and produce a catarrhal affection, with thickening and sclerosis of the mucous membrane, hyperostosis on the osseous walls and on the ossicula, or a suppurative inflammation. Kirchner found in the syphilitic diseased mucous membrane perivascular infiltration. The objective symptoms of syphilitic middle-ear suppuration are not particularly different from those of the genuine form. A. H. Buck observed in two cases characteristic syphilitic ulceration and swelling on the membrana tympani, together with a double perforation, accompanied by a marked syphilitic condition on the soft palate. The defect in hearing is generally great in most cases owing to the frequently accompanying syphilitic disease of the labyrinth. The course and result is various. With specific general and local treatment either healing occurs, or it proceeds to ulceration of the mucous membrane, with caries and necrosis of the walls of the tympanic cavity, mastoid process, and the petrous portion of the temporal bone; facial paralysis occurs, and a fatal result through brain and sinus affection follows. The prognosis is, therefore,

favourable only at the beginning of the affection in the slighter forms and in otherwise strong individuals; on the other hand, it is unfavourable in cachectic individuals, with the formation of granulations, polypi, caries, and total deafness. With energetic general treatment I have repeatedly seen healing occur even in severe cases. The treatment of the local disease is entirely antiseptic, and the alcohol or aqueous solution of corrosive sublimate, as recommended by Bürkner, serves a very good purpose. That this, as in other syphilitic ear affections, must give place to a general treatment of the symptoms need not be mentioned.

Treatment of Chronic Middle-ear Suppuration.—The treatment of chronic suppurative inflammation of the middle ear is in the first place determined by the local changes in the ear. It is essentially different in those forms in which the suppuration is associated with a simple infiltration and tumefaction of the mucous membrane, from that employed in forms in which granulations and polypoid proliferations in the tympanum and on the remnant of the membrana tympani and in the external meatus have been already developed, or when cholesteatomata have formed in the middle ear. The method of treatment frequently undergoes various modifications according to the quality and quantity of the secretion, the place and size of the perforation in the membrana tympani, the secondary changes in the external meatus, and, what must be particularly insisted on, the state of the general health at the time, as will be seen from the following account of the treatment of chronic suppuration of the middle ear in its different stages and conditions.

The first duty in the local treatment of chronic suppuration of the middle ear consists in the removal of the inflammatory infiltration of the mucous membrane, and in the arrest of the muco-purulent secretion. One of the most important conditions for the cure of chronic otorrhœa is the thorough cleansing of the middle ear from the masses of secretion, because, on account of its irregular pitted structure, these masses easily become stagnant, and becoming infected through the air may develop sepsis, and produce ulceration of the mucous membrane and of the bone.

In order to completely remove the secretion from the middle ear it must be forced into the meatus by means of a current of air through the tube. The method of the author is suitable in most cases, and the catheter is only necessary if there is too much resistance in the tube on account of excessive swelling, granulations, polypi, or desquamative products in the middle ear and meatus.

By means of the air-douche very often the secretion is only forced out of the anterior portion of the tympanic cavity, while the pus

lying in the posterior part of the cavity and mastoid cells is less affected. When on these accounts the secretion is not completely removed from the middle ear by the air-douche, the following methods may be used:

1. The blowing of air into the middle ear from the external meatus, by means of a small drainage tube, or a soft rubber tube (Fig. 228), rounded at its tip, passed in as far as the perforation. This means is often successful in forcing larger quantities of secretion from the middle ear into the meatus.

2. The condensation of air in the external meatus (Lucae) by which means a portion of the secretion is forced from the tympanic cavity into the pharynx.

3. The rarefaction of air in the external meatus (E. Politzer), which is often successful is aspirating large quantities of pus from the tympanic cavity into the meatus, when other methods are not successful.

After removal of the secretion from the tympanic cavity it should

FIG. 228.

be washed out of the meatus with a medium-sized syringe always kept aseptic. When there is slight resistance in the Eustachian tube more or less of the fluid will be forced through into the pharynx, so that most of the water used for syringing may pass through the nose. In many cases, owing to the sudden pressure on the fenestræ of the labyrinth by the injected fluid, such severe dizziness occurs that the patient will fall. The first injection should, therefore, be carefully done with slight pressure, in order to see its effect on the special case. The severest attacks of dizziness will be removed by the air-douche according to my method, or by rarefying the air in the external meatus.

The number of times the ear is to be syringed in the twenty-four hours is determined by the amount of secretion. The meatus should be syringed three or four times in profuse otorrhœa, but when the secretion is moderate, once or twice is sufficient.

As fluid for washing out the ear when the discharge is without odour, clean water previously boiled may be used, or a solution of cooking or Glauber's salts (Burckhardt-Merian) which dissolves the albumen of the purulent fluid. The temperature of the fluid should be about 26°-28° C. If the discharge has a bad odour, in place of the clear water should be used solutions of carbolic acid (2 to 3 per cent.), lysol (1 to 2 per cent.) or resorcin (2 to 3 per cent.), and in

obstinate sepsis a sublimate solution (0·1 to 0·2 in 1,000), which should not be used, however, in children, or where it flows into the pharynx. Instead of the sublimate may be used Alembroth as recommended by Lister (chloride of ammonia 4 parts, sublimate 1 part), in a $\frac{1}{200}$ per cent. solution. Besides these, a teaspoonful of a 10 per cent. alcoholic solution of salicylic acid to $\frac{1}{3}$ litre of water, a solution of pot. hypermanganate (10·0 to 200·0) or boric acid may be used as disinfecting medicaments. In profuse blennhorrhœic secretion which is obstinate to treatment, I have observed an immediate cessation of the discharge upon adding 4 to 5 drops of oleum terebinth. (not spirit. terebinth.) to $\frac{1}{5}$ litre of warm water used for syringing the ear.

Fig. 229.

The fluid which remains after syringing out the ear must be removed from the meatus by a tampon of cotton, in order to see the membrana tympani. If this is not sufficient, it should be wiped out with a piece of cotton fastened by a pincette or Burckhardt-Merian's cotton-holder (Fig. 229), while the meatus is well lighted with the reflector. In using the latter a flattened piece of charpie or boracic cotton-wool should be laid upon the ridged surface of the cotton-holder and twisted into a long pencil, which is shoved into the meatus nearly as far as the membrana tympani and then revolved in order to remove the secretion and fluid.

Although suppuration of the middle ear is not unfrequently cured by the injection of air into the tympanum, and by careful syringing of the ear, without further medication, yet experience shows that in many cases it is only by the use of medicinal agents that the infiltration of the mucous membrane can be resolved, and the arrest of the suppuration accomplished.

The medicinal agents used are applied to the mucous membrane of the middle ear in the form of solutions or as powders. Solutions must always be slightly warmed before instillation, for when cold they often produce pain and fits of giddiness. When the perforation of the membrana tympani is large the fluid will penetrate by its own weight into the tympanum, and wash the mucous membrane very thoroughly; but when the perforation is small, so that little if any of the solution reaches the middle ear, it is necessary to force the fluid into the tympanum, which is most simply done by pressing the tragus backwards and inwards over the

external orifice of the ear, and a part of the fluid frequently runs off through the Eustachian tube into the pharynx.

If the anterior half of the membrane is perforated, then by this process only the anterior portion of the tympanum and the Eustachian tube are washed. Therefore in order to make the remedy act also upon the posterior portions of the middle ear, the head must, during the compression, be bent not only to the side, but also somewhat backwards.

The compression of the fluid in the external meatus sometimes occasions severe vertigo. In such cases it is more advisable to inject air by my method, the head being bent to the side and the external meatus filled, by which means the air-bubbles escape through the meatus, whilst the fluid penetrates in their place into the tympanum.

By the use of this last method the tympanic cavity is often thoroughly cleansed by the solution and stagnant secretion removed. The injection of the remedy by means of the catheter, formerly much used, is now only resorted to in exceptional cases.

In the use of medicinal agents in a pulverized form we must be particularly careful that they are brought into direct contact with the diseased parts. For this purpose is used the insufflator made from my design by Reiner of Vienna, or one preferred by the user in which the amount of powder may be measured, or a glass cannula, rounded on the tip, furnished with a short india-rubber tube or a quill, with which the patient may himself perform the insufflation.

No decided opinion can at present be given concerning the mode of operation of medicinal agents. We know only this much, that by many drugs, especially by alcohol and pulverized substances, water is withdrawn from the diseased tissues; that other remedies, by their caustic operation, produce a strong reaction and a rapid change in the circulation and nutrition of the mucous membrane; and that further, by the chemical and mechanical irritation which many medicinal agents produce, the degeneration and absorption of the round cells infiltrated in the tissue take place, and that the antiseptics, owing to their anti-bacterial effects and their property of preventing sepsis and decomposition, have a beneficial effect upon the course of suppurative processes in the middle ear.

1. *The Antiseptic Treatment*, an acquisition of recent date, takes the first rank in the methods of treatment hitherto practised in cases of suppuration of the middle ear. We have already stated that the stagnation of the secretion is favoured by the irregular form of the tympanum. It is now known that in all cavities in which secretions stagnate for some time, decomposition of the secretion is begun by an excessive development of micro-organisms, especially when air is

admitted. It has been proved by experience that deeply penetrating ulcerative processes in the temporal bone may be produced by the penetration and development of certain forms of bacteria, and farther that by the immediate reception of micro-organisms into the blood a fatal result may be produced through septicæmia.

We thus have sufficient indications for the use of the antiseptic treatment in suppurations of the middle ear. Of course the carrying out of a regular, strict antisepsis in the ear is met with many difficulties (Bezold), because the admission of air through the Eustachian tube on the one side, and the meatus on the other, cannot be prevented. Nevertheless, by the careful cleansing of the ear—an important condition in antiseptic treatment—and by the anti-bacterial action of special medicinal agents, the development of causes of putrefaction is not only limited, but altogether prevented. One may be convinced of this by occasional microscopic examination of the secretion, and I consider it generally very important to repeatedly examine the secretion for micrococci during the course of treatment, especially in cases of offensive exudation, and in obstinate forms.

Among antiseptic remedies used in chronic middle-ear suppuration the most useful are: 1. Finely powdered boric acid (Bezold). Although in the chronic forms this does not have the marked effect which it has in acute middle-ear suppuration, yet the result is generally so good that the treatment of uncomplicated middle-ear suppuration should be begun with its use. The method of its application was described in the therapeutics of acute suppuration of the middle ear (p. 352).

As long as the suppuration continues, the boric acid is used once or twice daily—the secretion having always been previously removed. If the suppuration abates, then it is sufficient to blow the powder in every two days, and at last every three days.

There are cases in which the exudation ceases after the second or third insufflation of the powder; but on the whole a noticeable diminution of the secretion is only to be reckoned upon after some weeks of treatment. I have never observed bad results from the use of boric acid. Nevertheless, completely filling the meatus with the powder should be avoided, and, especially with moderate secretion, only a small quantity be insufflated.

Boric acid proves less beneficial in the blennorrhœal discharge, but I have sometimes seen rapid results if the powder is mixed with ol. terebinth. (Acidi borici pp. 5·0, ol. terebinth gtt. 5). When the secretion is of a septic character, I have found the boric acid very efficient if a few drops of carbolic acid was added to the powder (ac. boraci pp. 5, acidi carbolici gtt. 5). On the other hand, the

boric acid is often insufficient when the mucous membrane of the middle ear is excessively developed, in the formation of granulations in the middle or external ear, and in excessive desquamation in the meatus. 2. Carbolic acid (Hagen, Paulsen, Menière), which is most efficient in a weak alcoholic solution (Acidi carbol. 1·0, spirit. vini rectif., aq. destill. āā. 15·0, 15 to 20 drops warmed and dropped into the ear). Stronger solutions are detrimental. 3. Sublimate of mercury, in a watery or alcoholic solution (hydrarg. bichlor. 0·05, aq. destill. 50·0, or spirit. vini rectif., aq. destill. āā. 25·0, 15 to 20 drops instilled into the ear). This should not be used longer than two to three weeks if the effect is not sufficiently rapid. Where alcoholic solutions cannot be borne, aqueous solutions should alone be used, with which I have had good results, even in obstinate cases. 4. Iodoform, in many cases, has a very good effect; but, on account of its odour, cannot be used very well in practice. Its odour may be diminished by keeping a coffee-bean or a Tonka bean in the powder, by adding tinct. fabæ toncæ, or a few drops of ol. geranii. In private practice I use sticks of deodorized iodoform half cm. long (prepared with gum arabic and glycerine), which are introduced as far as the membrana tympani, and the meatus stopped with cotton-wool. 5. Iodol in powder, one of the same class as iodoform, but without odour, is not as efficient as iodoform, but has proved very beneficial in many cases, especially in scrofulous, tuberculous, and syphilitic suppuration. 6. Resorcin in 4 per cent. aqueous or alcoholic solution. 7. Salicylic acid in an aqueous (1 in 200) or alcoholic solution (2 to 5 per cent.). It often produces a severe reaction and otitis externa, and for this reason it is only exceptionally used. Of all these medicaments sometimes one, sometimes the other, proves more efficient, and the rule is, after the use of one medicament for 8 to 10 days without effect, another one should be tried.

Besides the medicaments mentioned here a number of antiseptic medicines have been recommended, of which some may produce a diminution of secretion in protracted middle-ear suppuration, when those already mentioned are without effect. These are: 1. Hydrogen peroxide, as recommended by Dayton, Rohrer, Bull, Boerne Bettmann, and Randall, in a 6 per cent. solution. This produces oxygen after its instillation with the formation of bubbles, which, according to Rohrer, will remove secretion remaining in the recesses of the ear. 2. Finely-powdered calomel (Gottstein), alone or combined with cooking salt. This has a slight corrosive action, producing for this reason a little pain, lasting for a few minutes. The application is repeated when the slight eschar is gone from the promontory. 3. Thymol (0·5 in 100). 4. Borate of sodium in solution, alkaline borate of sodium (Kafemann), or a mixture of borax solution (4 per cent.) with a solution of salicylic acid (5 per cent., Ogston), or the solution of neutral biborate of

sodium (Jänicke). 5. Hypermanganate of potassium (0·1-0·5 in 25·0), as lately recommended by Howe. 6. A weak solution of tincture of iodine (1 in 15 spirit. vin.). 7. Pulverized benzoic acid. 8. Boro-glyceride in a solution of 10-50 per cent. (Brandeis). 9. A mixture of iodoform and zinc oxide. 10. Asephol (C_6H_4OH, SO_2OH), recommended by Franchi; it is easily soluble in water, and is used in 1-4 per cent. solution for instillation, or is added to the water for syringing. 11. Salicylic acid chinoline in powdered form. 12. Aristol powder and dermatol, which was proved by Rohrer to be without effect. 13. Pyoctanin, 2 per cent. (Rohrer), inconstant in its action. 14. Naphthol (Haug). 15. Bismuth salicylicum (Delié).

2. *Alcohol Treatment.*—The use of alcohol in the treatment of chronic middle-ear suppuration as recommended by Löwenberg, and later by Weber-Liel and Cassells, has proved very valuable, especially where the antiseptics already mentioned are without effect. As concentrated alcohol often produces severe burning at the beginning of treatment, it is important at first to mix the acohol with two-thirds, or an equal quantity, of distilled water, and then to gradually increase the strength. The fluid is poured into the ear with a spoon previously warmed, and allowed to remain for 10 to 15 minutes, but should be rapidly removed if severe burning or pain is produced in the ear. The instillation should be done twice a day if the discharge is profuse, and when less intense once a day. In septic conditions of the secretion an alcoholic solution of boric acid (1 in 20), iodol (1 in 20), or carbolic acid (1 in 30), should be used; yet when the bad smell of the secretion is gone I return to the use of pure alcohol.

Immediately after the use of alcohol the saturated red mucous membrane on the promontory wall becomes a pale grayish colour, owing to the coagulation of the mucous and albumen on the surface. The beneficial effect is shown after its use for several days by a decreased secretion, and paleness of the mucous membrane.

The bad effects of alcohol treatment, as described by Manchen, I have never observed in my frequent use of this medicine, as I always begin with a diluted solution and increase gradually to the concentrated ones. When fulness of the head, headache, or dizziness occur after the instillation of alcohol, or when there is caries or a possibility of it being present, or in recurrent inflammation, it should not be used (Urban Pritchard).

Caustic Treatment.—The caustic treatment consists in the instillation of 15 to 20 drops of a warm concentrated solution of argentic nitrate (0·6-1·0 in 10·0-15·0 aqua dest.) into the meatus for the purpose of cauterizing the swollen and secreting mucous membrane, after previous careful syringing of the ear. The cauterizing is only seldom painful, and in a sensitive middle ear, mucous membrane

after the previous use of a 5 per cent. solution of cocaine (which should be washed out before the cauterization), the sensation of pain is only slight.

To form a proper eschar, the solution must remain in the ear at least one or two minutes. But when there is violent reaction, the ear should be syringed at once.

After each application, the excess of lunar caustic must be removed by syringing with simple lukewarm water. Neutralization, even with weak solutions of common salt, is not only superfluous but even injurious, in so far that the precipitates of chloride of silver formed in the tympanum remain firmly adherent to it. In private practice it is advisable to moisten the parts round the orifice of the ear with a solution of iodide of potassium after each cauterization, to prevent blackish-brown spots from appearing on the skin.

The eschar arising from the application is generally cast off within twenty-four hours, but sometimes not for two or three days. As a rule a second cauterization should not be performed until the eschar has been quite cast off from the mucous membrane.

The caustic treatment proves most useful in large defects of the membrana tympani, and with simple, not granular, swelling of the mucous membrane of the middle ear. It is contra-indicated in small perforations, with extensive granulations in the middle ear, in desquamative processes, and in caries of the temporal bone.

The effect of caustic treatment is manifested after its use for two to three times by a decrease or complete cessation of the suppuration. Often its use is without effect even after using for weeks, and in such cases a rapid decrease of the suppuration occurs when the treatment is changed to the use of boric acid, alcohol, or argill. acetica. In general the caustic treatment is less used at present than formerly.

Astringents.—The astringents which were formerly so much used in solutions: Sulph. zinc. (0·2-0·4 in 20·0), sacch. saturn. (0·2-0·4 in 20·0), cupr. sulph. (0·1 in 20·0), alum. crud. (0·3 in 20·0), acet. zinci (0·2 in 20·0), argill. acet. Burowii (*vide* p. 273) (1 in 3), are much less used in middle-ear suppuration since introduction of the antiseptic treatment. This may be understood if the detrimental effect of the insoluble metallic albuminate remaining in the middle ear is considered. The sacch. saturni and argill. acetica have the best effect, and I use the latter, especially when antiseptic and caustic treatment is without result, occasionally with good result. Alum powder in small amounts should only be used with large perforation, and on account of the gritty deposit only under careful observation.

Washing out the Tympanic Cavity through the Eustachian tube

by means of warm water (for the details of this method *vide* p. 109) is often accompanied by very favourable results in most obstinate cases of suppuration of the middle ear. I employ the injections simple, or with a slight addition of boric acid, in those cases in which no diminution of the secretion could be produced by the already mentioned methods. Syringing the cavity of the tympanum acts particularly favourably when there is a profuse blennorrhagic secretion, and when, on account of the rapid renewal of the secretion, the medicated agents applied from the meatus can be but imperfectly brought into contact with the mucous membrane of the middle ear. I have seen surprising results from this treatment in those complicated forms in which the excessively proliferating mucous membrane of the middle ear extends through the opening of the perforation into the external meatus, and also in those secondary infiltrations and constrictions of the external meatus which prevent medical treatment from this side. Where syringing through the Eustachian tube is not practicable, the method proposed by me for washing out the middle ear through the external meatus may be tried (p. 127). This method can only be used when the fluid, without symptoms of labyrinth pressure, flows easily through the tube into the naso-pharynx. After several applications of this method, I have seen rapid decrease and cessation of the discharge, and I am of the opinion that here, as well as by syringing per catheter, the beneficial effect is principally upon the mucous membrane of the tube from which the decrease of swelling of the mucous membrane of the middle ear proceeds.

The use of Saemann's water-douche (*vide* p. 123) could only be suitable in those cases in which there is suppuration of the middle ear, with perforation of the membrana tympani in both ears. The dry treatment of chronic middle-ear suppuration is only indicated when the secretion is perceptibly increased by syringing the ear, and when very severe dizziness occurs even in slight injections. In the majority of cases of chronic middle-ear suppuration, however, the washing out of the meatus is necessary to avoid sepsis in the ear; for by regular syringing of the ear the purulent discharge will be appreciably lessened, sepsis obviated, and the formation of granulations and polypi prevented. On the other hand, in neglected discharge from the ear, very often an offensive, inspissated secretion, filled with micrococci and vibriones, will be seen at the first examination, after the removal of which polypoid growths and granulations on the membrana tympani and on the mucous membrane of the middle ear are visible, the growth of which was undoubtedly due to the stagnant secretion.

The method of the dry treatment, which must always be done by the physician, is as follows: first, the secretion which has been forced into the meatus by the injection of air is removed as completely as possible with cotton. Then either a small tampon of antiseptic cotton-wool, or a pad of lint sprinkled with boracic powder, is pushed in as far as the membrana tympani, and changed every twelve or twenty-four hours, according to the profuseness of the secretion. In this manner the secretion is not only removed but the impregnating medicament is brought into use. Some prefer the following method: after the dry cleansing the tampon is removed, and then a considerable quantity of boracic powder is blown into the meatus; and if this is moistened by the following day it is again removed by being brushed out with a roll of lint or by moist boracic wadding.

Dry-cleansing is contra-indicated when the secretion is septic or in a crumbling condition, in desquamative processes in the ear, in the formation of granulations and polypi in the tympanic cavity, in caries of the temporal bone, or when the lining membrane of the meatus or the mucous membrane of the tympanum is in a very irritable state.

Treatment of Granular Middle-ear Suppuration.

The change in the mucous membrane of the middle ear consists in the development of numerous roundish or villous excrescences on its surface, which lend a granular appearance to the membrana tympani and to the promontory wall. The granular condition either extends over the whole mucous membrane of the middle ear, or affects only isolated parts of it (Figs. 176 and 177, p. 363).*

The granular form of suppuration of the middle ear is specially distinguished by its obstinacy, and its diagnosis is therefore important, because the suppuration does not cease until the granulations have been removed.† Although the granular middle-ear suppuration occasionally heals after the treatment with boric acid alone, yet

* I found, microscopically, small papillary formations upon the lining of the mastoid antrum and the cells in middle-ear suppuration.

† According to W. Meyer (*A. f. O.*, Bd. xx.), the granulations visible on the walls of the labyrinth always lie upon denuded bone, which can be located by a fine sound after removal of the growth. In my histological examinations I have frequently found the periosteal layer intact beneath the granulations. This superficial necrosis, the frequent cause of protracted middle-ear suppuration, according to Meyer, is the result of disturbance of nutrition in the non-vascular labyrinth wall. According to my view, the cause of deficient nutrition is to be found in the transmission of the inflammation from the mucous membrane to the bone along the connective-tissue prolongation of the periosteal layer in the promontorial wall, which were described by me (*vide* Fig. 40, p. 35).

a rapid result can only be obtained by cauterizing the granulations, through the operatic removal, or by using the alcohol treatment.

Removal of the granulations by cauterization is applicable when they are on the promontory or on parts of the inferior or posterior wall of the tympanum within view, where the cauterizing substance can be exactly applied to the proliferations.

The liq. ferri. muriat. s. sesqui chlorat. has proved the most efficient caustic I have tried. I have seen granulations on the membrana tympani and on the cicatrices of the membrana tympani disappear after one or two applications of the chloride of iron.

The application of the chloride of iron to the proliferation is most simply made by means of a probe dipped in the fluid, or with a small brush. The cauterization is seldom painful, especially if the mucous membrane has been painted with a 5 per cent. solution of cocaine, or the application of cocaine powder to the granulations. The cauterization should not be repeated until the eschar has been cast off. Solid nitrate of silver produces too much pain, and does not penetrate so deep into the tissues. Chromic acid cauterizes too deeply and causes too much pain, and should only be used in persistent cases and on the bases of fibrous polypi in the meatus. Lactic acid, which has been long recommended in a 15-30 per cent. solution dropped into the ear once a day, is much inferior to liq. ferri. in its effect. Acid. nitr. fumans, as recommended by Buck, requires too much precaution in its application, owing to the trouble in limiting it.

Galvano-caustic destruction of the granulations with pointed or rounded flexible cauteries is generally preferred to the other caustics. It has this advantage, that the violent pain lasts only for the moment of the operation, ceasing completely after the cauterization. The proliferations are more thoroughly destroyed than by other caustics, and severe reaction almost never results, and, as I have several times observed, the proliferations are shrivelled up even at the parts not touched by the cautery.

The operative treatment of granulations in the tympanic cavity is done by means of a small sharp spoon according to the method proposed by Oscar Wolf. This consists of a strong handle and a malleable rod of sound metal sufficiently strong, which ends in a sharp steel spoon. The spoon can be bent in different directions as wished. In order to do away with the bending Wolf uses a series of bent spoons, with which not only the granulations of the tympanic cavity, but also on the external meatus, on the membrana Shrapnelli, and on the incus and the hammer, may be removed. I

use a series of small sharp spoons made of steel (Fig. 230), prepared by Reiner of Vienna, which are fastened in a handle by means of a screw, and may be turned in different directions. By the instillation of a 5 per cent. solution of cocaine in the meatus, the removal of granulations with the spoon is nearly painless. Separate granulations which, after the scraping, still hang to the mucous membrane are removed either by syringing or come away spontaneously. The portion remaining must be cauterized, or made to shrink by the use of alcohol. It is often possible, besides the granulations, to scratch away particles of carious bone, and by this means to hasten the healing.

An excellent medicine for the removal of diffuse granulations in the tympanic cavity is alcohol. The method of using as well as the cautions to be observed have already been described. The result of this medicine is, however, slow, and it must be used for a long time twice a day. If the granulations are shrunk from the effect of the alcohol, as a rule the discharge also ceases. In a series of cases I have used the alcohol treatment together with cauterizing the granulations with good effect.

FIG. 230.

Treatment of Desquamative Middle-ear Suppuration and Cholesteatoma in the Temporal Bone.

The treatment of desquamative processes in the ear consists in the removal of cholesteatomous masses at the proper time, when its presence is proved by inspection, or from other symptoms which have already been described. The method of removing such masses depends upon the position of them, and varies very much according as it is in the lower or upper part of the tympanic cavity, in Prussak's space, or, lastly, in the mastoid process. The method of procedure will be further varied according as the opening in the membrana tympani is small or large, or whether a narrowing of the external meatus is present or not.

When the external meatus is of a normal size and the defect in the membrana tympani is large enough it is often possible to wash cholesteatomous masses from the lower and middle tympanic space

by simple syringing with considerable force. When the masses are more firmly adherent to the walls of the tympanic cavity, it is necessary before this is done to loosen them with a sound. If the simple syringing is not successful, a soft rubber-tube or an ordinary drainage-tube should be fastened to the syringe, and passed in to the deeper parts of the meatus, in order that the immediate effect of the stream of water may be brought to bear upon the masses of epidermis.

FIG. 231.

If the meatus is narrowed by a swelling, hyperostosis or exostosis, instead of a rubber tip to the syringe an elastic tympanic tube (Fig. 231) should be passed through the narrowed portion, and the mass behind the stricture washed out by strong syringing.

Also in collections of epidermal masses in the tympanic cavity, the removal of which is difficult on account of too small a perforation, I use, with advantage, an elastic tympanic tube, or hard rubber cannula, bent at right angles, ending in a fine point, which, after the instillation of cocaine (5 per cent.), is passed through the opening in the membrana tympani into the tympanic cavity. For the injection I use in place of the valve-syringe a small pear-shaped (50 to 60 grammes) rubber balloon, which allows of a more sure and less painful syringing. If it is not possible in small perforations of the membrana tympani to remove the mass of epidermis by means of repeated intra-tympanic injections, the operative enlargement of the perforation by means of a small rounded knife is indicated, after which the washing out of the tympanic cavity is easily done.

It is much more difficult to remove masses which are collected in the attic and mastoid antrum. Even with large perforations of the membrana tympani and strong injections into the external meatus it is scarcely possible to remove a portion of the cholesteatoma. Only by the injection through a properly-constructed cannula, by which the stream of water is directed against the cholesteatomous mass, is it possible to remove it from the tympanic cavity.

FIG. 232. — HARTMANN'S CANNULA. HALF-SIZE.

For this purpose Hartmann's cannula (Fig. 232), or the elastic cannula proposed by me and made by Reiner (Fig. 233), are especially suitable for the removal of cholesteatomous masses from the attic, as well as from the posterior superior quadrant of the tympanic cavity, when the perforation is

small, and in perforation of the membrana Shrapnelli. Their use produces scarcely any painful sensation.

If the injection from the external meatus proves without effect, or if it is impossible on account of narrowing of the meatus, the repeated injection of absolutely pure warm water, or 1 per cent. solution of resorcin, through the Eustachian tube, is necessary to completely wash out the tympanic cavity. By this means the thick masses in the tympanic cavity are dissolved, and a partial removal into the meatus is produced by their swelling. As through the entrance of fluid into the tympanic cavity dizziness, deafness, and pain may be produced by the sudden increase of tension, it is advisable to use the injection slowly. Both methods, the washing of the middle ear through the tube and the syringing of the external meatus, are often combined with benefit. The washing of the middle ear through the tube should be continued as long as the water contains epidermis flakes or greasy lumps.

The effect is often remarkable, as immediately after the removal

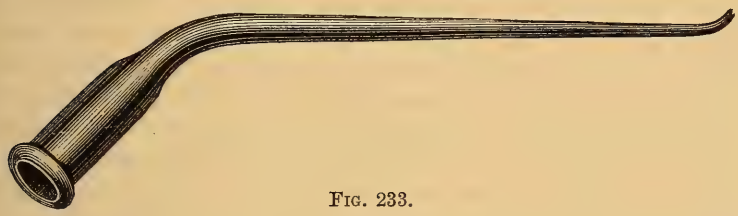

Fig. 233.

of the mass not only is the severe pain in the ear and the excessive pressure in the head alleviated, but, as I have repeatedly observed, threatening dangerous symptoms, such as vomiting, dizziness, stupefaction, chills, and facial paresis disappear very rapidly.

Treatment of Cholesteatoma and Suppuration in Prussak's Space and in the External Attic of the Tympanic Cavity.

The cholesteatomous collections in Prussak's space and in the external portion of the attic of the tympanic cavity require special methods for their removal. These cholesteatomata which occur from invasion often reach the size of a pea, and produce severe pain, dizziness and inflammatory swelling in the external meatus. Simple injections from the external meatus and also washing of the middle ear through the catheter are almost always unsuccessful, as the injected fluid does not enter the sacculated portion of the middle ear. On the other hand, by introducing Hartmann's cannula or my elastic cannula (Fig. 233), the connected mass may frequently be forced into

the meatus. To wash out the external attic on all sides the cannula must be rotated so that its point is directed forwards, upwards and posteriorly. Attacks of dizziness occurring during the syringing are removed by aspirating the air from the external meatus.

Small openings in Shrapnell's membrane which hinder the removal of cholesteatomous masses should be enlarged by incisions in different directions. If it is not possible to remove the cholesteatomous masses from the attic by means of injections, the sharp spoon and curette should be used for its removal (Fig. 230). These instruments may be used for the removal of small polypi and granulations from this cavity and to scrape the carious or softened edges of the margo tympani. The operative opening of the external attic in persistent forms of cholesteatoma, with the extraction of the malleus and incus when they are carious, will be described later, also the operative removal of cholesteatoma in the mastoid process will be described in the section ' Diseases of the Mastoid Process.'

As the pathological changes in the meatus during the course of middle-ear suppuration and after it, which are the source of secondary cholesteatoma, often remain after the removal of the epidermal production, it is the cause of their frequent return. Such patients must for years be examined every three or four months by the physician in order to remove newly collected masses. Frequent washing of the ear two or three times a week with a weak lukewarm solution of resorcin or boric acid and instillation of several drops of warm alcohol prove the surest means to prevent the recurrence in most cases. Siebenmann recommends the direct insufflation of boric and salicylic acid powder (1 in 4-10) into the cholesteatomous cavity.

Adherent crusts on the membrana tympani or in the tympanic cavity may be softened by introducing a tampon soaked in diluted glycerine, and after twenty-four hours they may be removed with the sound or pincette, or syringed out with warm water. In the latter case, to prevent the recurrence of the middle-ear suppuration, the water must be rapidly removed from the ear by the introduction of a plug of cotton.

In conclusion I will make some remarks as to the treatment of localized suppuration of the external attic with perforation of the membrana Shrapnelli. The special resistance of this form of middle-ear suppuration is either favoured by the sacculated shape of the external attic favouring sepsis, by caries of the malleus and incus, or lastly through caries of the margo tymp.; the latter is easily proved by sounding.

When with suppuration no caries in the region of the perforation in the membrana Shrapnelli is found at the first examination, anti-

septic treatment should alone be carried out, which is sometimes only successful after several months. As the secretion is almost always of a bad odour the attic must be washed out daily by the introduction of Hartmann's or the elastic cannula through the perforated Shrapnell's membrane and syringing with an antiseptic solution. The presence of gritty lumps in the water used for syringing signifies a continuing desquamation in the attic.

As solutions for syringing I have found most efficient resorcin (2 to 3 per cent.), sublimate (1 to 2,000) and carbolic acid solution (2 to 3 per cent.). After syringing the fluid remaining in the attic should be removed by forcing a current of air through the same cannula into the cavity by which it is dried. After this, with a small syringe, to which an elastic or solid cannula may be attached, several drops (10 to 15) of an alcoholic solution of boric acid, iodol, resorcin (1 in 20) or sublimate (0·02 in 20) should be warmed and injected into the cavity, and the meatus stopped with cotton-wool. Occasionally the insufflation of finely powdered boric acid in Prussak's space by means of a thin cannula or the author's powder-blower has a beneficial effect upon the suppuration.

If after several months' treatment healing does not occur, and the ill-smelling secretion continues in spite of energetic antiseptics, the external attic should be freely opened by the removal of the margo tymp. as far as possible. An index for the indication of this operation is found in the healing of suppuration at this portion by the opening of the attic through carious destruction of the margo tympani.

The opening of the external attic may be done by several methods. The most safe procedure consists in the successive scraping away of the margo tymp. bordering on the perforation in the membrana Shrapnelli, with a sharp spoon (as proposed by the author and then by Kretschmann). The operation must be done under narcosis with the patient in a sitting position and the head tightly fastened. The scraping is carried out with circular movements backwards and forwards, and on account of the dislocation of the malleus and incus one should be careful not to press the instrument inwards.

The removal of the osseous border on account of the inflammatory softening of the bone near the membrana Shrapnelli is much easier than farther above. The bleeding which often disturbs the operation must be frequently removed with iodoform gauze; after the operation the meatus should be irrigated with a lukewarm solution of salicylic or sublimate solution and a strip of iodoform gauze introduced into the operation opening.

The second method of opening the external attic consists in the removal of the margo tymp. by means of a forcep chisel made by Reiner.

This (Fig. 234) consists of a strong pair of nippers, the branches of which diverge; the anterior branch goes in a small horizontal groove, which has a steel plate 3 mm. broad and 2 mm. high at the anterior end. The posterior branch is connected with the steel chisel running in a groove. By pressing the branches together the chisel is moved against the anterior end of the groove.

This operative method is suitable for those cases of protracted sepsis in the external attic in which Shrapnell's membrane is destroyed and a portion of the margo tymp. already defective, and the opening being large enough to admit the anterior end of the instrument into the cavity. For small perforations the instrument must be so delicately constructed that the weak chisel will not perforate the bone. The operation should be carried out under narcosis, the patient being in a sitting position. After careful antiseptic washing out and drying of the suppurating cavity, the hook-shaped anterior end of the instrument is introduced into the opening and pressed against the border of the bone so that the external surface of the plate of the hook is against the inner side of the margo tymp. While the instrument is held against this the branches are pressed together by which the chisel cuts through the lamella of bone lying between it and the plate of the hook. This manipulation is repeated 10 or 15 times, during which the instrument must be removed 4 or 5 times in order to clean away the particles of bone. Also in this operation the dangerous pressure upon the ossicula should be avoided. The after-treatment is the same as by the first method.

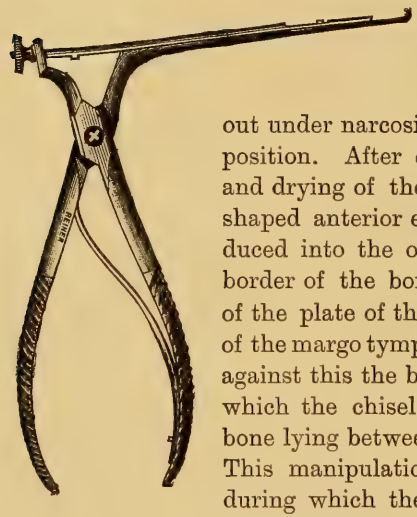

Fig. 234 (Half-size).

The chiselling away of the margo tymp. through the meatus is too unsafe, and there is great danger of dislocating the ossicula. As regards the indications for extraction of the hammer and incus, as well as the opening of the attic after loosening the auricle from its posterior insertion, they will be discussed in another section of this book.

Concluding Remarks on the Treatment of Chronic Middle-ear Suppuration.

From the above it may be gathered that in the treatment of chronic middle-ear suppuration the first indication is the removal of the stagnant secretion from the middle ear. Although certain medica-

ments prove, on the whole, more efficient, still in many cases the proper one can only be found by trying several. As, according to my experience, most preparations lose their efficacy after using them for some time, it is better after the use of one for several weeks to change to another medicament. The effect of an alternating use of the medicaments is often very much more rapid. Sometimes a medicament which has previously proved without effect after the use of another one will act very beneficially. That there are cases in which the suppuration is kept up by the use of medicines is proved by the cases in which suppuration ceases upon stopping all medicinal treatment and using only the simple syringing with the air-douche. Besides, cases of spontaneous healing without any local treatment often occur, as is shown by E. Weil's examination of school-children.

The treatment in chronic middle-ear suppuration, as a rule, should be continued without cessation as long as the suppuration continues, especially when one considers the bad results of a neglected discharge from the ear. With patients who are situated so that they cannot have the regular attendance of a physician, it is necessary to teach them or their relations about the necessary manipulation of syringing and use of the medicines.

The effect of the local treatment of chronic middle-ear suppuration is manifested frequently upon the whole system. Anæmic, emaciated children after the cessation of the discharge often present a rosy, healthy appearance.

That by the cessation of the suppuration the manifestation of certain general diseases may be prevented is shown by the fact that during chronic otorrhœa occasionally symptoms of scrofula and tuberculosis manifest themselves, and as in caseous ostitis of other bones (Buhl), from degeneration and resorption of caseated pus in the temporal bone, miliary tuberculosis may develop (v. Tröltsch).

In the internal treatment of chronic middle-ear suppuration, accompanying constitutional diseases are specially to be taken into account. This is specially true of anæmia, scrofula and syphilis, in which the local treatment is always to be combined with the proper internal treatment. As the same rules apply here as in middle-ear catarrh, in order to avoid repetition we would refer to the former description in ' Chronic Middle-ear Catarrh ' (p. 308), for the external medication, diet, change of air and climate, and the use of baths. The treatment of the naso-pharyngeal affections accompanying middle-ear suppuration will be considered in a special section.

After the cessation of suppuration of the middle-ear, one must abstain from the use of any local medication, for experience shows that the suppuration is easily brought back by syringing or instillation of remedies, as well as by

every irritative interference with the mucous membrane. Only where there is a tendency to relapse a small quantity of boracic powder may be insufflated once or twice a week after the cessation of the secretion, but without syringing the ear (Burckhardt-Merian). The ear should not be syringed out until the powder forms a thick layer, and it should then be carefully dried with absorbent cotton. The occasional instillation of warm alcohol in progressively increasing concentration proves very useful in the easily recurring cases, especially when there is a tendency to moist desquamation and in adhesive cicatricial formations between the membrana tympani and promontory, on the surface of which a slight secretion sometimes occurs. In these, as well as in other cases of adhesive new connective-tissue growth in the middle ear, I have seen a remarkable improvement in hearing after the instillation of alcohol for several weeks, and seldom a change for the worse. Where there is no improvement in hearing, or even increase of deafness occurs, after using the alcohol for several weeks, owing to retraction of the connective tissue, the alcohol must be stopped, and, if the local changes are favourable, operative treatment of the adhesive process should be done.

When the opening of the perforation does not become closed up on the cessation of suppuration of the middle ear, it is necessary for the prevention of relapses that the ear be protected from anything by which it might be injured from without. The tender, highly-irritable mucous membrane of the tympanum is protected from external influences by the membrana tympani itself, when that is intact; but when the membrane is perforated, the exposed mucous membrane is immediately affected by cold, wind, damp, dust, etc. Therefore the patient is strongly recommended to close the external orifice of the ear with a loose plug of cotton-wool or lint in stormy and damp weather, and in washing the ear to guard against the entrance into the tympanum of the fluid, and especially of cold water; for often merely by a few drops of cold water, which reach the tympanum through the opening of the perforation, the return of violent purulent inflammation may be occasioned.

a. Treatment of the Deafness.

The disturbance of hearing during and after the suppuration is best treated, in most cases, by the air-douche according to my method. Catheterization is more rarely necessary in this form than in the non-perforative middle-ear catarrh. The extent of improvement in hearing depends on the character of the changes in the middle ear. Too long continuation of the air-douche has a detrimental effect upon the hearing function; for this reason it should only be used two to three times a week, and after its use for four to five weeks should be followed by a pause of two to three weeks.

Only when there is a large amount of secretion should the air-douche be continued at short intervals to prevent its stagnation in the middle ear.

The rarefaction of air in the external meatus (p. 124), by which in localized suppuration the pus may be aspirated from the tympanic cavity into the external meatus, often improves the hearing after the cessation of the suppuration. A remarkable improvement in hearing, occasionally only temporary, is seen after the alternate use of condensation and rarefaction of air in the external meatus (massage) with Delstanche's masseur (Fig. 82). This procedure is indicated: in adhesions between the membrana tympani and the inner wall of the tympanic cavity; in adhesions of the membrana tympani with the articulation of the incus and stapes, or with the stapes when separated from the incus, especially in cases where, through cicatricial adhesions, the posterior portion of the tympanic cavity is separated from the anterior, so that the air-douche per tuba is without effect. The extraordinary improvement which occasionally follows the use of Lucae's pressure-sound is usually transient.

b. The Artificial Membrana Tympani.

We doubtless owe the invention of the artificial membrana tympani to the well-known observation of aural patients, who were surprised by the startling increase in the sharpness of their hearing when the remnant of the membrana tympani was touched in the attempt to remove the secretion lodged in the interior, by means of a rolled-up piece of paper or an ear-pick. Notes on the use of an artificial membrana tympani are found in the works of Marcus Banzer (*Disputatio de auditione læsa*, 1640), Autenrieth (*Tübinger Bl. f. Nat. u. Arzneik.*, vol. i., 1815), Itard, Deleau, and Linke (vol. ii., 1845), but the suggestions of these authors had little attention paid to them by aurists. In 1848 Yearsley, and in 1849 Erhard, proposed, independently of each other, the introduction of a ball of wadding as far as the remnant of the membrana tympani, in order to produce an improvement in the hearing in cases of perforation of the membrane; and soon after this (1852), Toynbee constructed the artificial membrana tympani which bears his name, and a series of good results was recorded, by which the attention of aurists was directed to this subject.

The high value of this invention is at once evident if we consider the number of aural patients at present who are suffering from purulent otitis media, with perforation of the membrana tympani, and who experienced no real improvement in their greatly impaired function from any kind of treatment whatever, while, by the use of the artificial membrana tympani their power of hearing is often so materially improved that they are, even after years of deafness, restored to unimpaired intercourse with those around them.

Toynbee's membrana tympani (Fig. 235) consists of a round india-rubber

plate 6 or 7 mm. in diameter, which is fixed on the end of a silver wire corresponding in length to the meatus. To unite the plate securely to the wire, it is advisable, as proposed by Lochner, to fix the centre of the plate between two little rings, which are formed by the silver wire terminating in a double spiral. Lucae fixed the plate on a thin india-rubber tube, Burckhardt-Merian on a solid strip of india-rubber, instead of on a metal wire. Fastening the india-rubber plate to a linen thread is so far impracticable in that its introduction into the ear by means of a cannula bearing the thread, or by forceps, is too troublesome, and also because the plate, when without a firm support, exercises too little pressure, and generally produces less improvement in the hearing than when it is fixed on wire.

FIG. 235. — TOYNBEE'S MEMBRANA TYMPANI.

FIG. 236.—ARTIFICIAL MEMBRANA TYMPANI FOR USE IN PRACTICE AMONG THE POOR.

FIG. 237.—HASSENSTEIN'S WADDING-BEARER.

As Toynbee's membrana tympani often becomes useless after several applications, I have invented for use among the poor, in order to spare patients the expense of procuring the instrument, an artificial membrana tympani, the manufacture of which is very easy and simple. A piece, ½ cm. long, is cut from the side of an india-rubber tube 2-3 mm. thick, and the lower end being perforated, it is fixed to a moderately strong wire, in the manner indicated in Fig. 236. In several cases in which attempts were made in vain with other artificial membranes, I have seen a striking increase in the hearing on the introduction as far as the remnant of the membrana tympani of an india-rubber tube corresponding to the length of the meatus, and rounded or obliquely cut off at the inner extremity.

Another modification of Toynbee's membrana tympani, designed by me, is its union with a stapes, taken from a dead body, for cases in which the crura have been destroyed by erosion, and only the base of the stapes is present in the fenestra ovalis. It is introduced so that the stapes, fastened by thread to the india-rubber plate, is made to lie in the niche of the fenestra ovalis. The waves of sound falling on the affixed stapes are conveyed by it to the foot-plate of the stapes in the fenestra ovalis.

Hassenstein's wadding-bearer (Fig. 237) consists of metal forceps, 3 cm. long, for holding a firmly rolled, longish pad of wadding. The branches of

the small instrument are so firmly held together by a little movable ring that the pad cannot fall from it. The larger the perforation of the membrana tympani, the firmer must be the front of the pad.

Hartmann's artificial membrana tympani is made of a slender piece of fish-bone, 5 cm. long and 2 mm. broad. One end of the bone is then bent backwards 1 cm., and, in common with its long part, wound round with wadding. Thus the bent part, being covered with wadding, easily fits into the deeper parts.

The cotton-carrier, invented by Ch. Delstanche, consists of a cotton-wool pencil or ball, twisted upon a thin metal wire, which the patient can prepare himself after being instructed.

The choice of the varieties of artificial membrane here described always depends upon their efficacy in the special case; and therefore for every patient for whom an artificial membrane is indicated, several forms must be tried, from which that is selected which acts most favourably. I seldom use Toynbee's membrane now, indeed only when it acts more favourably than the other forms. In my practice I more commonly use Hassenstein's and Delstanche's instruments. The disadvantage of Toynbee's is the troublesome rattling in the ear which occurs during speaking or chewing. This unpleasant effect is quite absent when Hassenstein's or Delstanche's instruments are used. These instruments, besides, act more favourably in most cases, and when the secretion is still going on, they offer this advantage, that the secretion is soaked up by the wadding, and that by applying wadding impregnated with boric or salicylic acid, or with an astringent, a curative action is at the same time in operation on the diseased mucous membrane of the middle ear. When Hassenstein's instrument is used, after the suppuration has ceased, the wadding may be soaked in oleum vaselini, as proposed by Clarence J. Blake. In many cases a simple ball of wadding, moistened with pure oleum vaselini, alone or mixed with zinc. oleinic. (1 in 10), can best be borne, this being introduced and again removed by means of forceps.

The introduction of the artificial membrana tympani is best effected by the patient himself, he having been previously instructed by the surgeon. As the efficacy of the instrument depends greatly upon the direction and quality of the pressure, the patient will, by practice, hit the right spot far more surely than the surgeon.

Although no improvement in the hearing may take place after the first application of the different forms of artificial membrane, one must by no means abstain from further attempts, for frequently, after repeated fruitless trials, one is surprised by the startling effect of the artificial membrane on its being tried once more after a few days.

The mode of action of the artificial membrana tympani has not been perfectly explained as yet. Toynbee's idea that the opening of the perforation is closed by the india-rubber plate and the resonance of the tympanic cavity thereby restored, has been proved erroneous by its having been shown that large perforations are not closed by the artificial membrane in cases in which this instrument has been successfully used. I have shown experimentally (*vide* p. 62) that waves of sound are conveyed by the india-rubber plate to the ossicula. Erhard's explanation is of considerable value, viz., that the artificial membrane acts chiefly by pressure on the remnant of the membrana tympani, and on the handle of the malleus, or on the part of the stapes separated from the incus, whereby the loosely articulated ossicula are pressed against each other, and the conduction of sound is improved. Whether the simultaneous variations in the intra-labyrinthine pressure have any influence on the increase in the hearing, as Lucae supposes, has not yet been proved.

Knapp thinks that by the pressure on the short process of the malleus—which of course lies across the axis of the malleus—the handle of the malleus, and with it the incus and stapes, turn somewhat outwards. The improvement in hearing is therefore produced by the chain of ossicula, which has been tightly pressed inwards, being turned outwards into a position approaching the normal one. By a series of experiments which I have made on patients, I have in several cases convinced myself of the truth of Knapp's theory.

The indication for the use of the artificial membrana tympani is present in all those cases of existing or exhausted suppuration of the middle ear in which the improvement in hearing necessary for common intercourse cannot be effected by local treatment. The size of the perforation in the membrana tympani is not determinative as to this indication, for even when the openings are small the effect is not unfrequently astonishing. Its use is contra-indicated when severe giddiness is set up by its application, when there is a reactive inflammation in the middle ear or in the meatus, or when suppuration returns after its use. Nor can it be used for children; the experiment in suitable cases should be confined to trying whether the instrument does affect the hearing-distance, in order to find out if it might be of use to the individual in question at a later date.

The degree of improvement in hearing on the introduction of the artificial membrana tympani varies greatly, and chiefly depends upon the anatomical changes in the middle ear. The increase in hearing is often so great that patients with whom one could formerly converse only when quite close to them, understand what is said at a distance of six or eight metres and more, after the artificial membrana tympani has been applied. In other cases the increase in hearing amounts only to one-third or one-half metre. Still, even this result is a great gain to many patients in so far that conversation is made much easier. Thus I have repeatedly seen persons

who, on account of their extreme deafness, were on the verge of losing their situations, enabled to retain them, their hearing having been so much improved by the artificial membrane that they could communicate with other people without difficulty.

The increase in hearing produced by the artificial membrana tympani certainly often disappears on the instrument being removed from the ear, but not unfrequently continues for a time. But cases in which a permanent improvement takes place, after the artificial membrana tympani has been used for some time, are more rare, and it is well gradually to accustom such patients to do without the membrane. According to my experience, after the artificial membrane has been applied for some time, a pause in its use for several days is generally required, for after such a pause the instrument exercises a much more favourable influence than when its use is uninterrupted.

This membrane, like every foreign body, causes irritation of the remnant of the membrana tympani and of the mucous membrane of the tympanum. The diseased parts must therefore be gradually accustomed to contact with the instrument. I allow it to be worn for half an hour only during the first four or five days, adding half an hour in every four or five days; six to eight hours daily should be the maximum for wearing it. As a rule the patient should use it only when he is conversing with others, and should lay it aside when he is alone. Before going to sleep instruments must always be removed from the ear, cleaned and dried, and the pad of cotton-wool must be changed every day by means of Hassenstein's forceps. If the secretion is still going on the ear must be syringed before and after the artificial membrane is applied, and occasionally a little boracic powder should be blown in, or one of the solutions previously mentioned should be dropped into the ear. In conclusion, it must be stated that even when the membrana tympani is not perforated, a not inconsiderable improvement in the hearing may frequently be produced by pressure on the membrana tympani, as is evident from the observations of v. Tröltsch, Menière, Pomeroy, myself, and others.

The Operative Treatment of Chronic Suppuration of the Middle Ear.

a. Operations During the Suppuration.

1. *The Enlargement of Small Perforations.*—This is indicated: (*a*) In cases of profuse blennorrhagic secretion, when the escape of the mucous masses through the narrow opening is prevented, and the symptoms of stagnant secretion are present. The enlargement

of the opening renders the penetration of air into the tympanum easier, and thereby enables a more thorough removal of the secretion from the middle ear to be made, as well as syringing of the tympanic cavity through the tube. The result is sometimes remarkable, sometimes only transient, owing to the rapid closure of the incision.

(*b*) In cases of small perforation, when violent symptoms of reaction appear in consequence of the retention of pus from the occasional agglutination of the edges of the wound, or from the obstruction of the opening in the membrana tympani by inspissated secretion.

(*c*) When there is an accumulation of cholesteatomous masses in the middle ear, which stop up the opening of the perforation, bulge out the membrana tympani, and, if left there long, may produce dangerous complications (*vide* p. 396). By the enlargement of the opening of the perforation not only is the obstacle to the escape of the masses into the meatus removed, but the introduction of the small tube throngh the perforation into the tympanic cavity, necessary to the liquefaction and removal of the secretion (p. 422), is rendered possible.

(*d*) When there are polypi and granulations in the tympanum, if the membrana tympani is bulged forwards by them, and the escape of the pus is obstructed. The dilatation is performed here in order to admit of the introduction into the tympanum of instruments necessary to the removal of the new formation, and to procure a free outlet for the stagnant pus.

(*e*) In cases of obstinate suppuration of 'the middle ear, when the small size of the perforation does not allow of the introduction of the tympanic tube or cannula used for washing out the tympanic cavity.

The operative procedure consists in the introduction of a paracentesis-needle or a small knife through the perforation, which is enlarged by an incision 3 to 4 mm. long. The incision must always be in that direction in which the greatest bulging forwards of the membrana tympani is seen. Immediately after the operation thick pus or polypoid masses often penetrate into the meatus. Severe reaction seldom follows the incision; only in a few attempts to enlarge the narrow opening of Shrapnell's membrane downwards have I seen severe infiltration and swelling developed in the membrana tympani and the meatus, accompanied by violent pain. In the majority of cases the edges of the incision unite in a day or two. It is then necessary to separate the coalescing edges by means of a probe or with the paracentesis-needle repeatedly.

2. *The Formation of a Second Perforation in the Membrana Tympani.*—This is indicated: (*a*) When loculæ and sacculations are formed in the tympanic cavity, if in some of these a purulent or mucous exudation is developed, accompanied by the objective and subjective symptoms already described (p. 384).

(*b*) When the membrana tympani is greatly bulged forwards at a distant part of the membrane from the perforation, if frequently-recurring pain renders retention of pus in the deeper portions probable; or when the suppuration continues obstinate, and as the cause of this may be assumed an accumulation of caseous substance or polypoid proliferations behind the arched part of the membrana tympani.

(*c*) In perforation of Shrapnell's membrane, if the symptoms of a collections of pus in the lower tympanic space (called Atrium tymp. in America) is present.

A second perforation has for its object not only the formation of a free outlet for the secretion, but also that an elastic or stiff tube may be introduced through the incision, for the purpose of syringing out the secretion, and the injection of medicated solutions into the suppurating cavity. Notwithstanding the fact that those partial suppurations limited to the superior posterior tympanic space or the external attic are generally very obstinate, I have repeatedly seen favourable results from washing out the cavity with an antiseptic solution, followed by the injection of a small quantity of a warm alcoholic solution of boric acid, sublimate, or iodol. Several times the aqueous solution of sublimate (0·5 in 50), where the alcoholic solution could not be borne, injected into the cavity has proved very beneficial. This is also true of the insertion of a cotton tampon soaked in sublimate solution, and the topical application of carbol. glycerine or fluid salol-camphrée (Salol 3·0, Camphor. rasæ 2.0 lique.). The latter fluid may often be used with benefit in chronic suppuration of the external attic with perforation of Shrapnell's membrane.

The extraction of carious ossicula will be described in the following section.

b. Intra-tympanic Operations after Suppuration of the Middle Ear is exhausted.

The operative treatment for disturbances of hearing caused by the adhesive processes after the suppuration of the middle ear is exhausted has a greater future than the operative treatment of the non-suppurative adhesive processes (Baseler Congressber., 1884). This opinion is supported by the comparative results from a considerable number of patients. For whilst in the case of adhesive processes which have arisen without suppuration (p. 309) the results

of the operative treatment are less favourable, and permanent only in isolated cases, we see in the case of adhesions caused by suppuration of the middle ear, after several operations, a striking improvement in the hearing, often continuing for years. My extensive experience in this direction within the last few years has substantiated this view.

The cause of the difference in the result probably lies in this, that in the non-suppurative forms the tendency to progressive shrinking and sclerosis of the new-formed connective tissue is incomparably greater than in the purulent processes; and, besides, in the important circumstance that the expansion of the auditory nerve in the labyrinth is much more rarely affected in the case of purulent otitis media than when the adhesive processes are non-purulent, in which latter the result of an operative procedure in the tympanic cavity is often an illusion.

Operations to improve the function of the hearing after the suppuration has ceased are only indicated if the deafness is serious, and if no increase in the hearing can be produced by the above methods of treatment, or when the adhesive process is accompanied by intense subjective noises or dizziness. It is always necessary first to ascertain the degree of mobility of the individual parts of the thickened or adherent membrana tympani and of the ossicula by injecting air into the tympanum, and then by Siegle's speculum, and, what is most important, to try the perceptive power of the auditory nerve through the cranial bones. Operation is permissible only if a low-ticking watch is heard through the cranial bones, and the duration of perception for a tuning-fork set upon the mastoid process is lengthened.

The results of the tympanic and intra-tympanic operations cannot be determined previously, as, besides the visible changes, there may be other complications which cannot be shown by objective examinations, and which preclude a favourable result. Every operative procedure should be regarded only as an experiment, and no positive result should be promised the patient. In general, circumscript adhesions offer a better prognosis than extensive flat ones.

The indications for operative treatment of adhesive processes after middle-ear suppuration has ceased are, according to my experience, as follows:

1. In severe deafness, owing to adhesions between the membrana tympani and the inner wall of the tympanic cavity, if on the surface of the membrane, besides irregular depressions, a projecting network is visible, by which the ossicula are rendered immovable.

If the tense fixation of the projecting strings is proved by examin-

ing with Siegle's speculum and the sound, their incision is indicated. For this purpose I use a small knife rounded on the end, with which one or two incisions are made at right angles to the course of the cords down to the promontorial wall. The results are specially good after incising such band-like formations, stretched between the retracted handle of the hammer and the articulation of the incus and stapes, as by the incision the rigid fixation of both the hammer and stapes is removed. Although the edges of the incision adhere again, the newly-formed cicatricial tissue rarely acquires the former rigidity, and for this reason in many cases a permanent improvement in hearing occurs, while in others it is only transient.

2. When the lower end of the handle of the malleus has adhered to the wall of the promontory, such abnormal adhesions of the handle

Fig. 238.

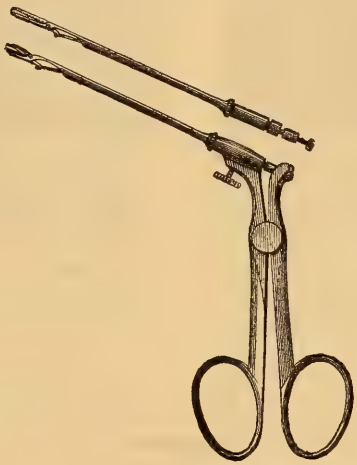

Fig. 239.—(Half Size.)

by which the incus and stapes are pressed strongly inwards, often occasion great disturbance of the hearing, which, as I have observed in many cases, is materially improved by repeated perpendicular incisions into the cicatricial tissue found in the immediate neighbourhood of the handle. If by adhesion of the hammer with the promontorial wall the articulation of the stapes and incus lies free behind the handle of the hammer (Fig. 242) and the incision of the cicatricial tissue around the handle is without result, the cutting through of the long process of the incus is indicated in order to remove the pressure from the stapes.

The instrument used for this purpose (Fig. 239) consists of a lever, bent at an angle to the anterior portion, which ends in a delicately-made short scissors, the branches of which are 4 mm. long and $\frac{1}{2}$ mm. wide. One of the

branches is immovably fixed to the instrument, while the other is connected with a projection extending to the angle of the instrument, and is opened and closed by a lever movement. The strength of the branches is sufficient to incise the long process of the incus without trouble.* In order to use the instrument for both ears, the upper portion is changeable by means of a screw.

The operation is carried out as follows: the instrument with closed branches is introduced in a horizontal direction nearly to the long process of the incus, when the scissors are opened, slightly advanced, and the long process of the incus, which may now be felt between the branches, is incised by closing the scissors. In order to prevent the adhesion of the incised ends,

FIG. 240.—FORMATION OF BAND-LIKE CORDS BETWEEN THE LOWER END OF THE HANDLE OF THE HAMMER AND THE STAPEDO-INCUDAL ARTICULATION. INCISION AT RIGHT ANGLES, ACCOMPANIED BY MARKED IMPROVEMENT IN HEARING.
In a man aged 48.

FIG. 241.—ADHESION OF THE LOWER END OF THE HANDLE OF THE HAMMER TO THE PROMONTORY.

FIG. 242.

as long a piece of the process is removed by a second incision as the size of the field for operation will permit. In several cases operated on by me the improvement in hearing was remarkable and permanent; in some, however, only transient or of no effect. In two cases, in which the incision of the cicatricial tissue around the adherent handle of the hammer had no effect and the articulation of the stapes and incus were not visible, after the cutting through of the handle of the hammer above the short process with the instrument described and the extraction of it with Sexton's pincette, a marked improvement in hearing resulted.

3. When there is a new connective-tissue formation in the posterior superior quadrant of the membrana tympani, so firmly adherent to the articulation of the incus with the stapes, or to the part of the stapes separated from the incus, and the neighbourhood of the niche, that the motion of the stapes is thereby impeded.

By a horizontal incision immediately beneath the capitulum of the stapes the cicatricial tissue is divided, and the stapes thereby more or less relaxed. When this fails to improve the hearing I make another incision parallel to the first immediately above the head of

* The instrument is made by H. Reiner, of Vienna, according to my direction.

the stapes if the long process of the incus is wanting. I perform the same operation when the inner wall of the tympanum is exposed and the niche of the fenestra ovalis is filled with shining gray cicatricial tissue, and the stapes is so fixed thereby that its capitulum, as examined by Siegle's speculum or by the probe, remains perfectly immovable. Sometimes the tendon of the stapedius appears enveloped in the cicatricial tissue surrounding the niche of the fenestra ovalis, and is then visible on the surface of the cicatrix as whitish projecting striæ extending backwards from the capitulum of the stapes. I have in several cases of this kind divided the muscle by an incision perpendicular to its length, and with good results as regards the improvement of the function of hearing.

4. In thickening and rigidity of the posterior portion of the mem-

Fig. 243.

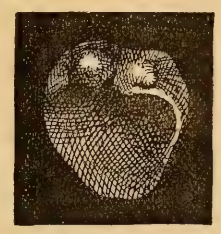

Fig. 244.—Fibrous Connective Tissue Formation in the Region of the Stapes.

Fig. 245. — Movable Cicatrix in front of the Handle of the Malleus. Rigid Edge of the Perforation adherent to Handle of Malleus. Incision of Edge of Perforation.

Before the operation: acoumeter = 10 cm., speech = 1 m.
After the operation: acoumeter = 55 cm., speech = 4 m.

brana tympani; with a very prominent posterior fold and accompanying retraction of the handle of the hammer; with band-shaped thickenings of the non-adherent membrana tympani by which the hammer is limited in its movement; and in thickening of the perforation edges, by which the handle of the hammer is rigidly fixed (Fig. 245). I have made repeated incisions in the thickened tissue with permanent beneficial effect.

Often the intra-tympanic operations already described alleviate or totally remove the subjective noises, dizziness, pressure and heaviness in the head. The improvement is either permanent or completely disappears after a few weeks or months.

5. *Operative Treatment for producing a Cicatrix to close up a Perforation of the Membrana Tympani.*—Cicatrization of perforations of

the membrana tympani is unquestionably of use in many cases, because, in the first place, the majority of the waves of sound are conveyed by the new-formed cicatrix to the ossicular chain; and, in the second place, by the closure of the opening the mucous membrane of the tympanum is protected from the injurious effects of cold, dust, and damp. But in other cases cicatrization of the gap in the membrana tympani may even impair the hearing-power of the individual, namely, when there exist on the malleus or incus obstacles to the conduction of sound, or when the stapes has been isolated by the wearing away of the long process of the incus. In such cases sound-waves which, during the persistence of the perforation, could fall directly on the stapes, meet with great resistance at the malleus and incus when a cicatrix has been formed, and, as is shown by repeated observations, there not only results great deafness, but sometimes also violent tinnitus.

From this it is clear that when an attempt to close the opening in the membrana tympani is about to be made, one must always first ascertain whether greater harm will not result from the cicatrization. Therefore, as a preliminary experiment, it is advisable to stop up small perforations with a little drop of thin glycerine on the point of a probe, and larger openings with a little bit of moistened paper or silk, and then to examine the hearing-power. The operation is permissible only if the hearing-distance is thus increased, or at least not diminished.

The simplest method of inducing the formation of cicatricial tissue on the margins of the perforation consists in freshening them by slight cauterization with a globule of lunar caustic, melted on to the point of a probe. The epidermic covering of the margin of the perforation is destroyed by the cauterization, and a reaction is produced which not unfrequently leads to new formation. In this way I have seen perforations of from 3 to 4 mm. in diameter, reduced to 1 mm. and less. In one case an opening the size of a lentil was reduced to that of a pin-point without its being possible to produce by continued cauterization its complete closure.

After the margin of the perforation has been cauterized, there frequently results, however, reactive inflammation of the membrana tympani, which spreads to the mucous membrane of the tympanum, and sets up again a long continued suppuration of the middle ear. If, in such cases, the attempt to arrest the secretion be successful, the opening is generally found to be still larger than before, in consequence of the previous suppuration.

Another method by which the formation of a cicatrix may be produced consists in making several incisions in the margin of the perforation. But this operation is not only very painful, but also produces, much oftener than cauterization, a reactive suppuration of the middle ear; and when this is exhausted the gap in the membrana tympani is, as a rule, larger than before the operation.

Cl. J. Blake has recommended covering the opening of the perforation with a sheet of moistened paper of corresponding size for the purpose of inducing the formation of cicatricial tissue. Not only is the mucous membrane of the tympanum protected by this means from external injurious influences, but the margins of the perforation also are easily irritated, and the gap is diminished by the gradual formation of new tissue. Complete closure of old perforations has not been obtained by this method.

Myringo-plasty has recently been proposed by Berthold* as a new operative treatment for closing persistent perforations. The margins of the wound are freshened by applying a piece of adhesive plaster across the opening of the perforation. This is removed in three days, and a piece of skin, taken from the arm, is lightly pressed on the surface of the wound at the edges of the perforation. Experiments which I have made on living beings as to the practicability of this operation for various sizes of perforations show that only when the openings are small, or under 3 mm. in width, can the application of the transplanted piece to the edges of the perforation on all sides be performed with certainty, and that in larger perforations one rarely succeeds in making the piece fit exactly, because the edges of the perforation are on different levels. I am not able to judge of the positive results of this operation.

6. The keeping of perforations open when they have a tendency to cicatrize is only successful in rare cases. The indication for this treatment is present in all cases in which, when the perforation has been temporarily closed by secretion or by epidermic masses, a striking decrease in the hearing-power results, which disappears when these have been removed. The introduction of lead cannulas or the other methods of destroying the growing cicatrix by the probe or the cautery often cause a return of the suppuration and rarely produce the desired effect.

The restoration of a perforation closed by cicatricial tissue is indicated in cases in which, as long as the opening existed, the power of hearing was not materially diminished, but immediately after the cicatrization of the gap, intense deafness and severe tinnitus set in, and where, therefore, there is probably an impediment to the conduction of sound at the malleus or incus, the stapes being free and movable.

The methods hitherto proposed for destroying the cicatrix by caustics or the galvano-cautery have not yielded favourable results in so far that purulent inflammations frequently took place, and the closure of the opening could not be prevented. The mildest treatment is to split the cicatrix with a paracentesis-needle, and to insert a vulcanite eyelet into the restored opening. This method, which was described in detail, p. 312, is, however, only suitable for small, free cicatrices, 2 to $2\frac{1}{2}$ mm. in size, and serves to keep the gap in the membrana tympani open only for a time; for observations have hitherto shown that by wearing the eyelet for some time suppuration is set

* *Tagebl. d.* 51, *Naturforschervers. in Cassel*, 1878.

up, or else the eyelet moves away from its place towards the periphery and falls out, or is closed by secretion.

In conclusion, there remains to be mentioned the making of multiple incisions into relaxed cicatrices, first proposed by me. This operation is indicated in cases of depressed relaxed cicatrices, when the deafness is diminished by bulging the cicatrix outwards, and when the same degree of disturbance of the hearing reappears when the cicatrix has returned to its former position. In these cases there result from the several incisions circumscribed condensations in the relaxed cicatrix, whereby its resistance is materially increased, and, with it, the vibrating power of the whole membrana tympani.

Carious Affections of the Temporal Bone developed in the Course of Suppuration of the Middle Ear.

Etiology and Occurrence.—The occurrence of ulcerative osseous affections in the course of suppuration of the middle ear, the significance of which has already been pointed out, is due sometimes to certain local changes in the ear, sometimes to constitutional taint, especially to tuberculosis, scrofula, syphilis, marasmus, and other cachexiæ. Among the more important local changes are the following: stricture of the external meatus, polypi and granulations leading to retention of pus in the middle ear, stagnation, thickening, caseation, and decomposition of the purulent secretion in the air-spaces of the temporal bone, and finally catarrhal ulceration and wasting of the mucous membrane, extending in some places to the complete laying bare of the walls of the middle ear down to the osseous tissue. That in many cases we have to deal with a deeply penetrating disturbance in nutrition in the bone due to micro-parasitic origin, and that the caries is often due to tuberculous, and occasionally to an osteomyelitic process in the bone, is without doubt.

Caries of the temporal bone is developed more frequently in the course of acute purulent inflammation of the middle ear, especially in the scarlatinal, tubercular, syphilitic, or typhoid forms, or with measles, than in chronic suppuration of the middle ear. It occurs more frequently in children than in adults (Sexton). Its extent varies greatly. Between the slight circumscribed caries, not larger than a pin-head, and the extensive inflammation and destruction involving almost the whole of the temporal bone, there are found numerous variations in the extent of the osseous affection. The most extensive destructions are found in those cases depending on scarlatina or tuberculosis. The pneumatic and diploëtic portions of the temporal bone are more frequently the seat of caries than the compact bone substance into which the micro-organisms exciting the

inflammation cannot enter so easily (Steinbrügge). The mastoid process and part of the posterior superior wall of the meatus adjoining it are most commonly affected; more rarely comes caries of the walls of the tympanum, especially of the tegmen tympani and the promontory; the pars petrosa, the anterior wall of the meatus and the squamous portion of the temporal bone. The process may confine itself to one of the portions named, but frequently it is found that several portions are carious and necrosed at the same time; often the mastoid process and the external meatus, or the mastoid process and the posterior portion of the pars petrosa, and lastly, the greater part of the temporal bone may be involved in the ulcerative process; indeed, the affection of the bones may spread from the temporal to the neighbouring cranial bones, most frequently to the occipital bone,

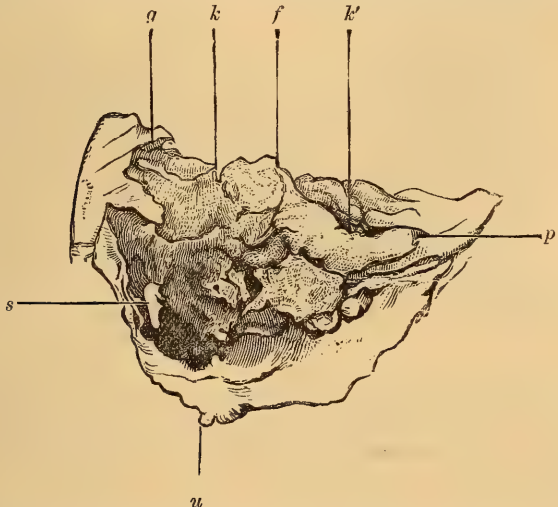

FIG. 246.—VIEW OF THE POSTERIOR SURFACE OF THE PYRAMID. EXTENSIVE NECROTIC DESTRUCTION OF THE PETROUS PORTION OF THE TEMPORAL BONE.
From a scrofulous girl, aged 22, who died of an abscess of the cerebellum. The whole petrous portion is broken into a number of loose pieces of bone connected with each other (*g*, *k*, *k'*, *f*, *v*, *u*). The capsule of the labyrinth is detached from its surroundings. *s*, Perforated sigmoid sinus. (After a preparation in my collection.)

more rarely to the zygoma, the parietal bone, or the cervical vertebræ.

Caries and necrosis spreading from the middle ear always lead, according to the extent and depth of the ulceration, to important changes in regard to the capacity of the middle ear and the meatus.

From degeneration and absorption of the osseous tissue, or from necrosis and exfoliation of bone in masses, there arises at individual places considerable enlargement of the cavities, and consequently increased communication between the meatus, the mastoid process,

and the tympanum; while at other parts, especially in the vicinity of carious portions, the cavity is considerably contracted by diffuse, sclerosed osteophytes, or more frequently by flat, reticularly fenestrated ones (Zuckerkandl). The latter rise to a considerable height on the walls of the air-spaces in the mastoid process in chronic inflammation of the middle ear, or are at first filled with granulation tissue, which afterwards becomes ossified into a solid mass.

Simultaneously with caries of the temporal bone, one generally finds extensive changes in the lining membrane of the middle ear and of the meatus, as well as in the membrana tympani and in the ossicula. The mucous membrane is not unfrequently found to be

FIG. 247.—MICROSCOPIC SECTION OF THE CARIOUS ARTICULATION OF THE MALLEUS AND INCUS IN A WOMAN, 32 YEARS OLD, WHO DIED FROM AN ABSCESS IN THE CEREBELLUM, AND WHO HAD SUFFERED FROM OTORRHŒA FROM CHILDHOOD.

a, Head of malleus; *b*, Body of the incus; *c*, Capsular ligament; *d*, Cavity of the joint opened by erosion of the capsular ligament; *e e'*, Enlarged osseous spaces filled with round cells.

ulcerated, or changed into a spongy granulation tissue, wholly or partially filling the cavities of the middle ear, and growing out into the meatus, or studded with polypoid proliferations. The dirty-gray and bad-coloured granulations, often filled with micro-organisms, which spring up in the region of carious and necrotic collections and upon carious bases as well as caseous degenerated masses of cholesteatoma, hinder the healing of the bone disease. The lining membrane of the meatus, especially in its osseous portions, appears infiltrated, undermined, or loosened; the membrana tympani to a great extent destroyed or degenerated with the formation of polypi (v. Tröltsch), very seldom wholly or partially united to the inner wall of the tympanum; the ossicula loosely articulated, carious, or exfoliated. The spaces not filled with proliferations of mucous

membrane contain offensive, caseous, or greasy masses, or blood and exfoliated spiculæ of bone, mixed with grumous fluid, rarely with cholesteatomous epidermic masses.

Caries of the ossicula occurs either independently or as a complication of caries of other portions of the temporal bone. The destruction is usually confined to one of the bones, more rarely the whole chain is affected. Most frequently the head of the malleus and body of the incus are affected; in isolated caries the incus is more frequently affected than the malleus; caries of the stapes is more rare.

Caries of the malleus most frequently affects the capitulum, but this very seldom exists independently, being generally combined with caries and necrosis of the body of the incus. In such cases the ulceration commonly spreads to the interior of the bone from the inner surface of the articulation of the malleus and incus (Fig. 246).

The destruction is sometimes so extensive that one finds either only small eroded remains of the head of the malleus and of the body of the incus, generally embedded in granulation tissue, or else the head of the malleus quite absent, so that it appears to be sharply cut off above the short process.

Fig. 248.—Frontal Section through the Right Pelvis Ovalis after the cessation of a Middle-ear Suppuration.

f, Upper; *pr*, Lower wall of the niche; *d p*, Newly-formed connective tissue filling the pelvis ovalis; *d*, Epidermal covering of the connective-tissue growth on the inner wall of the tympanic cavity; *p*, Plate of the stapes perforated in several places.

The handle of the malleus, as long as it is surrounded by the tissue of the membrana tympani, rarely becomes carious. It is only when the inflammation extends to the periosteum itself that lacunar caries occurs with destruction of the bone (Moos) by granulation tissue and giant cells.

In cases of caries of the handle of the malleus its lower portion is generally lost, but it is rarely so completely destroyed that only the head and a little stump at the short process are left.

The short process of the incus is seldom destroyed, but the long process is very frequently, often indeed in the course of simple suppuration of the middle ear with swelling and secretion, uncomplicated with caries of other parts, or with the formation of granulations. This is probably produced by softening and atrophy of the bone, caused by the continual action of the secretion on the long process of the incus, which is exposed on all sides. The importance of the interruption of the conduction of sound between the

membrana tympani and the stapes, arising from the loss of the long process of the incus, has already been brought forward among the consequences of chronic inflammation of the middle ear. Occasionally the whole incus is destroyed by caries.

The head and the crura of the stapes are most commonly destroyed; sometimes the destruction is so complete that only the foot-plate in the fenestra ovalis remains. This withstands the carious destruction the longest.

Necrosis and exfoliation of the whole malleus by itself, without caries of the walls of the tympanum, is very rare indeed. A case of this kind reported by O. Wolf (*Z. f. O.*, vol. x.) deserves special attention, because it did not arise from exudative necrosis after an acute infectious disease, but apparently from an independent ostitis of the malleus. Only the head and handle were slightly eroded. The hammer, which was otherwise well preserved, was removed from the ear by syringing, and no marked disturbance of hearing remained after cicatrization of the perforation.

Softening of the ossicula (head and crura of the stapes), probably consequent upon their being deprived of their lime by the purulent secretion, was observed by Hartmann and Bezold.

The suppurative process in the middle ear leads further to slackening and to partial or entire luxation of the articulations, through inflammatory destruction of the capsular ligaments, even without caries of the ossicula. Mutual displacement and separation of the joints is also frequently caused by the pressure of inspissated masses or granulations upon the ossicula, or by the direct penetration of such substances into the cavities of the joints. Dislocation most frequently occurs at the articulation of the stapes with the incus, more rarely at that of the malleus with the incus, whereby the incus is pushed against the antrum mastoideum, or suppurates away, so that only the malleus and the stapes are found post-mortem.

The separation of the articulation of the malleus and the incus almost always occasions a change in the position of the malleus, especially when the handle is exposed and the check-ligaments are relaxed. The malleus then appears almost rotated on its axis, and hanging either from the tensor tendon or lig. mall. ant. I saw a most striking case of this kind in a man who had suffered for many years from suppuration of the right middle ear. The malleus, hanging by its anterior ligament, appeared so twisted round upon its axis that its head was turned downwards and outwards towards the lumen of the meatus, but the handle inwards towards the upper space of the tympanum.

The union of the edges of the stapes with the fenestra ovalis is also often so relaxed that the stapes falls out of the fenestra ovalis at the least touch with the probe (Schwartze). Yet at post-mortem examinations in which the membrana tympani, the malleus, and the incus are wanting, the stapes is most frequently found still preserved.

Besides the ligaments of the joints, the ligaments and check-ligaments uniting the ossicula with the walls of the tympanum, as well as the muscular tendons, are sometimes also relaxed and destroyed by the suppurative process, so that some or all of the ossicula suppurate away spontaneously, or are removed by syringing.

Symptoms of Caries of the Temporal Bone.—Of the subjective symptoms of caries of the temporal bone pain is generally the most prominent. This, which is usually very intense and permanent, is not always in proportion to the extent of the carious process, for sometimes very limited ulcerations of the bone are associated with violent pain, whilst in other cases, especially in tuberculous and scrofulous persons, caries, with the formation of extensive sequestra, often runs its course altogether without pain. The cause of the pain lies sometimes in the inflammation of the periosteum and of the bone accompanying the ulcerative process, sometimes in the retention of the secretion, in which case the most intense pain will often decrease if the pus escapes spontaneously or is removed artificially. The pain often ceases also when the formation of sequestra is completed, but sometimes enclosed sequestra, or those partially adhering to the non-necrosed bones, are the cause of obstinate pain, which only ceases on the removal of the dead bone. Occasionally neuralgic pain accompanies the caries.

The following are frequent symptoms of caries, but by no means constant or characteristic: severe subjective noises, vertigo and vomiting, stupefaction, great irritability of the nervous system, occasional excitement, and sleeplessness, accelerated pulse, occasional chills and increase of the fever temperature especially towards evening; tinnitus and dizziness, which are present at the beginning of the labyrinth necrosis, often disappear after the demarcation of the sequestra is complete.

The objective signs of caries of the temporal bone are much more important. These are very variable, and by no means always so pronounced that we may infer from them that there is ulceration or necrosis deep in the bone. Still, the nature of the discharge and the changes in the external meatus and in the neighbourhood of the ear which accompany caries, and also not unfrequently functional disturbances in the area of the facial nerve, offer important grounds for supposing, most probably with justice, that caries does exist.

The discharge, especially when the caries is extensive, is very copious, and thick like cream, though it is often thin like meat-washings, and bloody, offensive, and corrosive. Only rarely does it contain sediments of bone. The suppuration may occasionally stagnate or suddenly cease entirely, if the escape of the secretion is prevented by constriction of the meatus, by granulations, or by the presence of sequestra.

The consecutive changes in the external meatus are diffuse swelling, infiltration, and ulceration of the cutis, with the outbreak of granulations and polypoid proliferations in the osseous portion, and

ulceration on the inferior cartilaginous wall. The frequent occurrence of bulging of the cutis of the upper and posterior wall of the meatus is of much greater importance. This occurs from the extension of the inflammation of the middle ear to the air-cells and diploëtic-spaces between the laminæ of the upper wall of the meatus (v. Tröltsch), or from caries of the mastoid process extending from the posterior superior wall of the meatus. There often result periostitis, infiltration, undermining and separation of the periosteum and the cutis by collections of pus, and, in consequence, a bulging of the wall of the meatus to such an extent that the bulged-out cutis reaches the floor of the meatus, and the lumen of the canal is quite obliterated. Such bulging of the lining membrane of the meatus, when frequently recurring or continuing long, must be regarded as an unfavourable complication in suppuration of the middle ear.

Bulging of the upper wall of the meatus generally takes place with violent pain, and is rarely painless. Resolution occurs either spontaneously or from treatment, especially when the tympanum has been washed out per tubam with warm water; or it goes on often only after some weeks to rupture of the hard resistant cutis, with discharge of fluid or caseous pus, cholesteatomous masses, or necrosed pieces of bone from the meatus and the mastoid process. It rarely happens that part of the cartilage of the meatus is laid bare and eroded by the suppuration so that its jagged edges project into the cavity of the abscess or freely into the lumen of the canal.

After spontaneous rupture or artificial opening of such bulgings careful probing of the parts is necessary. By carefully probing one can often ascertain with certainty the extent of the loosening of the wall of the meatus, the length and direction of fistulous canals, the locality and size of carious parts, possible communications between the meatus and the mastoid process, and the presence of a sequestrum.

In consequence of caries of the temporal bone, extensive inflammatory collections and abscesses are often formed in the neighbourhood of the ear. Their most frequent site is about the mastoid process and the region below the auricle, more rarely in front of the ear. They arise either from the extension of the inflammation from the bones or soft parts of the temporal bone to the surrounding parts, or from ulceration, rupture, sinking of the pus in the neighbouring tissue, or, lastly, without immediate connection with the morbid collection in the temporal bone, from the extension of the inflammation, by means of the blood and lymphatic vessels, to the soft parts surrounding the temporal bone.

The objective appearance varies greatly. Sometimes the region of the mastoid process is found to be much infiltrated, swollen, hard, or fluctuating, the auricle standing out from the head, and either normal or infiltrated; sometimes again in purulent infiltration of the lower wall of the meatus, and in caries and rupture into the interior of the mastoid process, a hard, painful swelling beneath the auricle, affecting the lateral cervical region, is found caused by infiltration of the subcutaneous connective tissue of the parotid and cervical glands. Occasionally the inflammation spreads on the one side to the occipital and cervical regions (with contraction of the cervical muscles), and on the other to the crown of the head and the face. Erysipelas even sometimes occurs in the auricular region with great œdema of the face and eyelids, and may spread to the face, and even to the other side of the head, and along the neck to the thorax and the upper arm.

If it advances to the formation of an abscess in the parts surrounding the ear, then the pus either makes its way into the external meatus by bursting through the cartilage, one of the fissures of Santorini, or the membranous lamina completing the cartilaginous channel, or it works its way to the surface of the skin on the external auricular region, breaks out in front of or behind the ear, and escapes externally; occasionally the pus penetrates inwards to the naso-pharyngeal space, where it may result in a retro-pharyngeal abscess (Chimani). The cavity of the abscess in the part round the ear may close up quickly if it has no direct communication with the carious tissue, but if there is a direct communication between the abscess and the carious tissue, then the spot where the abscess has broken through often becomes a fistulous opening, which generally remains so for years, usually until the deep osseous disease is cured.

There is great diversity in the site of these fistulæ, whose walls generally consist of infiltrated, callous tissue, or covered with bad discoloured granulations, often defying every attempt at treatment. They most frequently arise in the region of the mastoid process, sometimes under the auricle, and in front of the tragus. Fistulous canals communicating with the carious substance in the temporal bone not uncommonly open at distant parts, such as at the occiput, the cervical region, or, as in a case observed by me, in the supra-clavicular region. The number of these openings also varies. There is often only one opening, but sometimes there arise at different periods, close together or separated by a considerable distance, fistulous openings which communicate with each other directly or by their canals opening into the carious cavity. Sometimes a fistulous opening cicatrizes, and another breaks out at a different place.

A frequent symptom of caries developing in the temporal bone in the course of suppuration of the middle ear is paresis and paralysis of the facial nerve.

Lesions within the area of the facial nerve are caused:

1. By inflammation, without caries of the osseous canal, spreading from the mucous membrane of the middle ear to the osseous walls of the Fallopian canal, and to the sheath of the facial nerve. These are the more favourable forms of facial paresis in suppuration of the middle ear, for after resolution of the inflammation in the Fallopian canal, and absorption of the exudation, the paralysis completely disappears. Congenital gaps in the Fallopian canal favour, as already mentioned, the development of facial paralysis in cases of suppuration of the middle ear.

My observations show that slight facial paresis, only perceptible on close examination, is much more frequent than has been supposed in simple cases of chronic suppuration of the middle ear. Marked facial paralysis was seen in only 1 per cent. of cases with middle-ear suppuration by Bezold. The observations of Wilde, v. Tröltsch, Tillmanus, etc., show that facial paresis sometimes occurs even in cases of simple, non-perforating catarrh.

2. By caries and necrosis of the Fallopian canal, if the inflammation and destruction extend to the facial nerve. But caries of the Fallopian canal is not always followed by paralysis of the facial nerve, for records of post-mortem examinations show that a great part of the portion of the facial nerve which enters the tympanum may be laid bare either by congenital fissures or by caries of the osseous canal, and be bathed in pus without any sign of facial paralysis having been perceived during life.

Facial paralysis is generally unilateral. Bilateral paralysis of the facial nerve occurs but rarely in suppuration of the middle ear. A peculiarly wooden and immovable expression is characteristic of such bilateral total facial paralysis. In a case observed by v. Tröltsch (*Lehrbuch*, p. 481), the corneæ were partly dried in consequence of ectropion of the under lids, the under lip hung loosely down, and the chin had to be pushed up in speaking and in eating.

The degree of facial paralysis varies according as transmission is interrupted only in certain bundles, or in the whole nerve trunk. In the former case the different branches of the facial nerve are unequally affected, so that the paralysis is sometimes most pronounced in the upper branches stretching towards the forehead and the orbicularis palpebrarum, and sometimes in the lower branches going off towards the nose and the angle of the mouth. General, though slight, paresis of the facial nerve points to diminished conducting-power in the whole nerve trunk. But complete and persisting

paralysis affecting all the ramifications of the nerve affords grounds for concluding that there is a deep-seated lesion and interruption of their conducting-power.

Along with the well-known symptoms of paralysis of the facial muscles, there is also sometimes found paralysis of the muscles of the soft palate on the side affected, perceptible on phonation.

The effect of the electric current on the paralyzed nerve and muscles varies greatly. In slight cases the reaction is often normal or somewhat increased. In severe cases the muscles of the side affected especially exhibit an abnormal reaction. The Faradic contractility of the muscles at the beginning of the disease is frequently increased (Erb, Benedikt), but diminishes rapidly in its further course till it is quite lost, while the muscles respond more strongly to the galvanic current than do those on the normal side. In cases of advanced atrophy of the nerve and muscles, galvanic contractility also entirely disappears. When recovery or material improvement commences in such cases, electric contractility, according to Benedikt, returns in inverse order to that in which it was lost.

Sometimes severe pain in the ear and in the corresponding side of the face precedes the development of facial paralysis, but at other times there is not the least pain, and the paralysis is introduced by twitchings of the facial muscles (spasmodic tic), which may last for a shorter or longer period; or, lastly, the paralysis may come on quite suddenly, without any premonitory symptoms.

In paresis the condition varies greatly during the course of the disease. If improvement or recovery occurs, it does not always affect all the ramifications of the nerve equally, for some branches remain paralyzed longer than others. Recovery is sometimes limited to certain branches, while the paretic condition continues permanently in the area of distribution of others.

The results of facial paralysis are: (1) Complete recovery in those cases in which the inflammation, which has extended to the facial nerve, is fully resolved. (2) Persistent paresis of the whole nerve or of certain of its branches, when by thickening and retraction of the neurilemma the conducting-power of the nerve is impaired, or when individual nerve-bundles have their function destroyed by ulceration, induration, or fatty degeneration. (3) Complete and persistent paralysis of the facial nerve, when the conducting-power of the nerve trunk has been destroyed by ulceration or formation of indurated masses. The results of such paralysis are secondary atrophy of the facial muscles, rarely also of the corresponding half of the jaw, permanent conjunctival catarrh, and, when the corresponding side of the palate is paralyzed, secondary catarrh of the

middle ear on the previously healthy side, due to the insufficient ventilation of the normal ear.

Although, according to the foregoing, secondary facial paralysis is not always of unfavourable prognosis, still its appearance in the course of suppuration of the middle ear must always be regarded as serious, for it is often the forerunner of a fatal cerebral affection, more rarely of a fatal sinus-thrombosis. Long continuance of the normal response of the nerve to electric irritation (constant current) is generally to be regarded as a favourable symptom, while rapid diminution of the response is unfavourable (Erb). The prognosis is also more serious when there occurs rapid total paralysis with visible caries and necrosis in the interior of the ear.

Diagnosis of Caries and Necrosis in the Temporal Bone.—The diagnosis of caries and necrosis of the temporal bone, especially when the affection is deep-seated and when striking symptoms are wanting, is very difficult, and often quite impossible. A diagnosis can be made with certainty only when objective knowledge of the carious and necrosed parts, or a sequestrum can be touched by the point of the probe. Probing is specially important in the recognition of caries and necrosis if the bare bone is overgrown with granulation tissue, or so completely concealed by it that nothing can be seen of the sequestrum on examination with the speculum.

But although the use of the probe is so important in the diagnosis of caries of the petrous bone, we must most emphatically point out the dangers. For from coarse manipulation with the probe not only may dislocation of the ossicula occur, but also in caries of the already thinned inner wall of the tympanum, the brittle bony lamella may easily give way when roughly probed, with the result of a flow of pus into the cavity of the labyrinth. But besides this, rough probing may also have dangerous consequences, by opening into certain spaces in the diploë, into which the pus may penetrate, and thence enter the venous passages in the skull and general circulation.

When examination with the probe yields no positive result, it is only from the coincidence of several symptoms that caries of the temporal bone may with probability be assumed to exist. Thus we may consider it as highly probable that there is ulceration of the temporal bone in cases of persistent or frequently recurring pain in the ear, with a copious or offensive discharge like meat-washings, when at the same time the osseous meatus is constricted by infiltration or bulging of its lining membrane, or by polypoid proliferations, or in cases of frequently recurring abscesses in the parts round the ear.

It remains to be stated that in all chronic middle-ear suppurations in which the suppuration persistently continues in spite of long-continued local treatment, one is justified in concluding that the cause is to be found in a latent caries of some portion of the temporal bone.

Prognosis of Caries of the Temporal Bone.—The prognosis of caries depends upon the character of the ulcerative process, its locality, and partly on its extent. The chances of limiting the ulceration are greatest in otherwise healthy patients, in superficial caries, and when the local conditions are favourable to the escape of the secretion and the removal of the sequestrum. On the other hand, the prognosis is unfavourable in individuals suffering from constitutional diseases, especially tuberculosis, scrofula, inveterate syphilis, and marasmus, also in deep-seated caries of the pyramid or of the mastoid process, in strictures of the meatus, in abnormal adhesion of the membrana tympani to the inner wall of the tympanum, and in extensive formation of granulations in the middle ear, which leads to the retention of the putrid secretion in the interior, and prevents the removal of inspissated masses.

The extent of the ulceration of the bone has less influence on the prognosis with regard to fatal results, for, as we shall see, a very limited caries confined to the roof of the tympanum sometimes leads to rupture into the cranial cavity, while in extensive caries, reaching to the dura mater and the venous sinuses, a great part of the temporal bone may form a sequestrum, and be ejected without causing a fatal result. Still, the hearing function is generally destroyed to a greater degree when the caries and necrosis are extensive than when the affection is limited. When in Weber's test the tuning-fork is only heard in the ear which is not affected, a suspicion at once arises of a labyrinth affection due to the carious process.

The Course and Result of Caries of the Temporal Bone.—The course of caries of the temporal bone is either acute, with rapid destruction of tissue and formation of sequestra in the bone, especially in tuberculous, scarlatino-diphtheritic and syphilitic middle-ear suppuration, or the ulceration runs a chronic, slow course, and only after long duration ends by the formation of a sequestrum. Not unfrequently an occasional pause during its course occurs, which is succeeded by an exacerbation of the destructive ostitis, either gradually or with violent symptoms of reaction. The caries may even be entirely cured at one part of the temporal bone, and then break out again after some months or years at another part or in the neighbourhood of the former inflammation.

The results of caries and necrosis of the temporal bone are:

1. Recovery without material deformity of the framework of the temporal bone. This result is most frequent in caries of the superficial osseous lamella of the external meatus and of the middle ear.

2. Recovery with permanent loss of osseous tissue. The destruction may occur with a gradual absorption of the bone-tissue spreading from the surface to the interior, which leads to confluence of the spaces of the temporal bone by disappearance of the intermediate walls, or by the exfoliation of necrosed fragments of bone in the form of irregular, rough, and sometimes much fenestrated sequestra.

3. Extension of the carious suppuration to the cranial cavity and the venous sinus, with frequent fatal termination from meningitis, abscess of the brain or sinus phlebitis.

4. Destruction of the wall of the carotid canal and the sinus lateralis with fatal result from hæmorrhage.

5. Fatal result due to reception of septic material, from the carious and necrotic parts in the temporal bone, into the blood (pyæmia), or from some general disease extending from the local affection (tuberculosis, marasmus).

The formation of sequestra in the temporal bone sometimes goes on very rapidly, especially in the course of scarlet fever in children, but generally it is slow. By the presence of the sequestrum in the carious cavity profuse suppuration and the formation of new granulations are almost always maintained, while on the removal of the fragment of bone, the suppuration generally rapidly decreases and the proliferations soon shrivel up. Violent pains, convulsions, and vomiting (Moos) often cease on the removal of sequestra. Sometimes the sequestrum wanders from its original situation, frequently from the mastoid process and the tympanum to the external meatus, more rarely, as in one of my cases, from the mastoid process into the tympanic cavity. Sequestra of the labyrinth either remain in their original situation or enter the tympanum and then the external meatus.

The size and form of exfoliated necrosed fragments of the temporal bone depend upon the site and extent of the caries. The sequestrum is either in one piece or in several fragments. In children very extensive destruction and exfoliating necrosis occur just as in adults.

Superficial necrosis limited to the osseous meatus is localized, as I have repeatedly noticed in tuberculous individuals, on the inner portion of the posterior superior wall, which is exfoliated in the form of a curved, bow-shaped, jagged lamella, with a part of the sulcus tympanicus visible on its inner edge. Such sequestra are generally covered over with granulation-tissue, and may be extracted with small polypus-forceps after they have been loosened with the probe. In children whole pieces of the annulus tympanicus, and rarely, as I saw in one case, both annuli tympanici (Fig. 249) are completely necrosed and discharged as sequestra, on which the sulcus tympanicus is generally quite visible.

Circumscribed, superficial necrosis of the walls of the tympanic cavity, according to my observations, most commonly affects the external osseous layer of the promontory, which is thrown off in the form of thin, serrated laminæ, among which there is sometimes a piece of the sulcus Jacobsonii, indicating the seat of the necrosis. In other cases there is developed, in consequence of ulcerative destruction of the mucous membrane, without any visible separation of particles of bone, an ulcer in the bone of the promontory, penetrating to the lamella of the labyrinth, and receiving a worm-eaten, ragged appearance from the numerous ridges and depressions of the inner wall of the tympanum. Superficial sequestra on the outer and superior wall of the tympanum are rare.

Of greater extent and importance is the formation of sequestra in cases of deep-seated caries. This is almost never confined to one portion of the temporal bone, but if so is most frequently limited to the mastoid process and the labyrinth. More frequently sequestra are formed at the same time in parts of the meatus and of the mastoid process, or of the mastoid process and the

FIG. 249.—ANNULI TYMPANICI NECROSED AND EXFOLIATED DURING SCARLATINOUS SUPPURATION OF THE MIDDLE EAR.

a, *a'*, Sulc. tymp. From preparations in my collection.

FIG. 250.
Twice the actual size.

pyramid, or of a great part of the temporal bone with parts of the meatus, the squamous bone, the mastoid process, and the labyrinth.

The literature of diseases of the ear is rich in examples of necrosis and spontaneous exfoliation of great parts of the temporal bone. Voltolini (*M. f. O.*, 1874) saw, in the case of a child of twenty-two months, an exfoliation of the annulus tympanicus with part of the pars squamosa and mastoid, which took place in the course of a syphilitic suppuration of the right middle ear. Michael (*Z. f. O.*, vol. viii.) extracted from the left ear of a child of three years several sequestra, and among them the upper portion of the inner wall of the tympanum containing the greater part of the fenestra ovalis and part of the facial canal which runs over it. Not unfrequently single parts of the labyrinth, or the whole of it, are exfoliated. Most frequently, as is shown by the observations of Toynbee, Menière, Lucae, Dennert (*A. f. O.*, vol. x.), Cassells, Shaw, Pomeroy, Schwartze, Richey (*Chicago Med. Journal*, vol. xxvi.), Gruber, Pareidt, etc., the cochlea forms the sequestrum owing to the caries and necrosis penetrating from the inner wall of the tympanum to the labyrinth. In the case of a girl of seven years, observed by me, after two years' chronic suppuration of the left middle ear, a polypus appeared growing from the tympanum; and on its removal a sequestrum was seen in the

interior, which, on being extracted, proved to be the cochlea with the whole modiolus and with the greater part of the osseous lamina spiralis (Fig. 250). On testing the hearing, there was found to be total deafness on the left side; the tuning-fork applied to the vertex was only perceived by the right ear. In the case of a girl of eight years, Guye extracted the semicircular canals with a part of the vestibule as sequestra from the opened mastoid process. In this case, the absence of all disturbances of co-ordination was interesting. Cases of sequestra consisting of the whole labyrinth are rarer. Of such deserving of mention is a sequestrum described by Toynbee (*A. f. O.*, vol. i.), which included the whole labyrinth, with the internal meatus and the commencement of the facial canal. Wilde describes a sequestrum extracted by Sir Philip Crampton, which consisted of the whole labyrinth and the inner wall of the tympanum. This case is also so far interesting, in that a unilateral paresis of the extremities disappeared on the removal of the sequestrum. In the case of a child, Voltolini likewise extracted the whole labyrinth, and described (*M. f. O.*, 1870) a similar preparation which was removed from the ear by Jacobi. Ch. Delstanche (*A. f. O.*, vol. x.), in the case of a scrofulous child of six years, removed, along with necrosed parts of the osseous meatus, the complete osseous labyrinth, of which only one of the semicircular canals was wanting. At the Milan Congress, 1880 (*A. f. O.*, vol. xvi.), Gottstein showed a sequestrum extracted from the region of the mastoid process (girl of eight), in which were perceptible a part of the squamous bone, of the ann. tymp., of the mastoid process, and of the labyrinth with the fenestra ovalis. In a case observed by Moos of a man with caries of the petrous bone, and who had suffered for a week from violent vertigo and vomiting without fever or cerebral symptoms, there followed on the extraction of an exfoliated osseous semicircular canal from the external meatus complete disappearance of these symptoms. But discharge of the sequestrum does not always take place; it may remain in the interior, and be found post-mortem in the temporal bone, as recorded by Toynbee (*l. c.*), v. Tröltsch (*Virch. Arch.*, vol. xvii.), and shown by several preparations in my collection.

According to Bezold (*A. f. O.*, Bd. xvi.) among 41 cases gathered from the literature, and 5 of his own, about 20 per cent. of the cases of labyrinth necrosis die from consecutive brain and sinus affection.

Labyrinth necrosis produces complete deafness in most cases. Yet with erosion of the semicircular canals there may be sensations of sound if the pus has not extended to the cochlea. After necrotic destruction of the cochlea the perception for speech and tones is lost. The observations published of cases where the perception for speech and musical tones was present after exfoliation of the cochlea, is due to an error, as the hearing of the other ear cannot be entirely excluded (Hartmann, Bezold, Politzer).

That cure is possible in spite of extensive destruction of the petrous bone, reaching almost to the dura mater, is due to the proliferation of connective tissue on the outer side of the dura mater, while the osseous ulceration is extending to it, whereby a protecting wall is raised against the approaching suppurative process

This has been shown by the proliferation of the connective tissue of the external meatus, observed by Wendt, which in the case of a sequestrum of the pyramid prevented the suppuration from spreading to the base of the skull. Similar changes, new growth of connective tissue, hyperostosis, and osteo-sclerosis are found on other parts of the petrous portion of the temporal bone, forming a wall at the edge of the carious-necrotic collection as a protection from the progressive destructive process.

When the sequestrum has been discharged or removed, the cavity formed by the loss of substance is either rapidly filled up with granulations which ossify after being changed into fibrous connective tissue (callus), or the walls become overgrown even in the presence of the sequestrum with a thin layer of connective tissue covered with epithelium, which on the removal of the sequestrum often forms a basis for the deposit of laminated cholesteatomatous masses.

As formerly mentioned, after caries and necrosis of the temporal bone are exhausted there frequently remain abnormal cavities and a confluence of the spaces of the meatus, the mastoid process, and the tympanum, and also fistulous openings round the ear. Often, however, through exostosis and hyperostosis, they end not only in obliteration of the cavities formed by the necrosis, but also in narrowing and obliteration of parts of the tympanic cavity and of the meatus, or in obliteration of the whole tympanic cavity, and in atresia of the external meatus, which is closed at a varying depth with an unyielding osseous mass like a cul-de-sac. These changes result of course in deafness of a high degree, or even in total deafness.

The Treatment of the Carious Processes in the Temporal Bone.—In the treatment of caries of the temporal bone the most thorough removal of the stagnating secretion from the deeper parts must first be effected. This is one of the chief conditions for the limitation of the caries, and for preventing its advance to the cranial cavity. The methods of washing out the tympanic cavity, as well as the choice of antiseptic solution, have been already discussed (p. 418). If the meatus is filled with granulations of polypi, they must be immediately removed (*vide* Polypi). In narrowing due to undermining of the upper and posterior wall with pus, extensive incisions in the prominent portions are indicated in order to remove the pus or caseous masses. In more extensive narrowing near the membrana tympani thin elastic tubes should be passed behind the narrowed portion, and the secretion washed out with a solution of boric acid, carbolic acid, or lysol solution, or with a weak solution of sodium chloride (1 per cent.). The contracted portions of the meatus must be dilated as speedily as possible by the insertion of wedge-shaped

pledgets of lint or antiseptic wadding of progressively increasing size, or of short drainage-tubes.

Syringing the tympanic cavity through the Eustachian tube with warm water, or with a weak solution of borax or salt, has proved very useful in my practice. The injections not only wash out putrid secretions and caseous masses, but also frequently rapidly remove or alleviate the violent pains in the ear and head which accompany caries. I attach all the more importance to this procedure in the treatment of caries, that the subjective symptoms, in my experience, are never so quickly removed by any other local application as by syringing the tympanic cavity per tubam. When the pain cannot be alleviated, subcutaneous injections of morphia must be used.

The local treatment is seldom accompanied by result. Cauterizing with argentic nitrate, chromic acid, or with the galvano-cautery, are only of use in limited superficial caries of the meatus wall, and should not be tried in caries of the promontorial wall. Instillation of dilute sulphuric acid (1 in 3, Mathewson) and hydrochloric acid, tincture of iodine, trichloride of iodine (Trautmann), lactic acid (Aysaguer), as well as powdered iodol, aristol, and sozoiodol, act only as antiseptics, as they frequently remove the bad odour without affecting the extension of the caries.

The operative treatment of caries often gives brilliant results. Its use was first indicated by the results of opening the mastoid process and laying free the attic. In caries of the inner wall of the tympanic cavity, it is only in circumscribed superficial roughness that careful scraping with a skilful hand and a small delicately made instrument is allowable.

Moreover, all interference, especially scraping of carious spots on the bone, is to be avoided in cases of evident caries of the inner wall of the tympanic cavity, as the thin osseous wall separating the tympanic cavity from the labyrinth may be fenestrated by a trifling pressure, and the labyrinth laid open. In caries of the auditory canal, the scraping out of rough pieces of denuded bone by means of Oscar Wolf's sharp scoop (p. 420) can only be successful if applied to caries of the superficial lamellæ ; but if the disease of the bone is more deeply seated the scraping out is without success. As it is not possible to tell by sounding, whether the caries is superficial or deep, it would be well, in every case in which there is evidence of a carious spot in the meatus, to try scraping out to a depth of 1 to 2 mm. A deeper penetration is to be avoided, especially on the upper wall of the meatus, on account of the vicinity of the cranial cavity.

After having scraped the diseased bone it is well to blow iodoform or iodol powder upon the denuded parts, by which means the

suppuration is diminished, and the rapid formation of healthy granulation tissue, changing to cicatricial tissue, is most effectually brought about.

The method of removing an exfoliated sequestrum from the ear is regulated by its size, form, and position, as well as by the relative capacity of the external meatus. The smaller the exfoliated piece of bone, the more readily will it be removed by strong injections or by the forceps. The greater the size and the more irregular the form of the sequestrum, and the narrower the meatus, the more difficult is the extraction. But the removal of small sequestra frequently presents difficulties, more especially when they are deeply seated or so much embedded in granulation tissue that the sequestrum can be seized only after tearing away the granulations.

The extraction from the external meatus of larger sequestra, originating usually in the mastoid process, more rarely in the pyramid of the petrous bone, is only permissible by means of the dressing forceps, when this can be accomplished without the exertion of too much force. Extraction, however, should not be attempted when the sequestrum is known to be too large for the lumen of the external meatus, for, by the use of force, angular sequestra with sharp projections might cause injury to the infiltrated cutis and to the cartilage of the meatus, setting up a widespread and sometimes erysipelatous inflammation in the neighbourhood of the ear, and leaving tight stricture of the meatus as a later result.

Fig. 251.

In the case of large sequestra not removable by simple extraction, cautious crushing of the bone may be recommended as the surest method. For this purpose I use a pair of sharp bone forceps made of good steel, of the form and size of the accompanying drawing (Fig. 251), by means of which, during anæsthesia, the sequestrum can be crushed into several small pieces. In the case of a girl four years old, in whom a flat sequestrum more than 1 cm. broad, firmly adherent with its flat surface external, could not possibly be laid hold of, it was extracted by means of an incision of corresponding size on the posterior cartilaginous wall of the meatus; cicatrization of the tolerably wide incision followed shortly after, in spite of the continuance of the otorrhœa. This treatment has also been recommended by Schwartze.

Although in the treatment of caries of the petrous bone most importance is to be attached to local applications, yet these must be combined with general treatment suited to the constitution of the

individual. In the case of debilitated patients in particular, when, as is so frequent in caries, the pulse is quick, or in the evenings a high temperature comes on, with acceleration of the pulse, moderate doses of quinine are to be recommended, or salicylate of soda (1 to 2 grms.). Preparations of iron in cases of anæmia are only suitable when digestion has not been destroyed. On the other hand, when the pain is of long duration large doses of iodide of potassium internally are recommended ($\frac{1}{2}$ to 1 grm. daily), when not contra-indicated by tuberculosis or great debility. Mineral water containing iodine, iodine baths, and the use of simple thermal springs, are in many instances most effectual in limiting the local affection, as well as in raising the general tone.

Treatment of Facial Paralysis.—This coincides with the treatment of suppuration of the middle ear and of carious affections of the petrous bone. At the beginning of the affection, more especially when it commences with violent pain in the ear, indicating the probability of recent inflammation of the bone, large doses of iodide of potassium (0·5 to 1·0 daily) may be of much service. The effect, moreover, may be increased by the embrocation of ointments containing iodine, iodoform, or iodol with the addition of morphia or the extr. laud. aquos. on the mastoid process and in the vicinity of the ear.

Galvanic treatment is to be employed only when signs of reaction have disappeared, and no symptoms exist which threaten danger. The result is often favourable, and in my practice I have met repeatedly with cases in which paralysis of the face of long duration, and not improving under treatment with iodine, has been removed, or substantially improved by the use of the galvanic current. When the paralysis lasts for a lengthened period, especially after the cure of caries and cessation of the suppuration, and when ulceration or the formation of callus may be supposed to be its cause, it must of course be understood that then all treatment will be useless, and in such cases the employment of the Faradic current will only have as its object to counteract the atrophy of the muscles on the affected side. In isolated cases, even with long continuance of paralysis after caries, I have myself observed a marked improvement result from the use of iodine baths and of simple thermal springs.

The Extraction of the Ossicula in Chronic Middle-ear Suppuration.

The removal of the remainder of the membrana tympani with the hammer and incus in chronic middle-ear suppuration was first proposed by Kessel (1885) for those cases in which the tympanic cavity was divided into separate spaces by polypoid growths, so that an

antiseptic treatment was impossible from mechanical reasons. By this operation, with removal of the granulations, a smooth-walled cavity is procured in which the suppuration may be stopped by the proper treatment.

Indications.—The indications for the extraction of the hammer and eventually also the incus may be grouped as follows:

1. Obstinate middle-ear suppuration which withstands all local treatment, accompanied by caries of the hammer.

2. Retarded flow of pus from the upper tympanic spaces, when this continues in spite of long-continued antiseptic treatment and occasionally accompanied by painful swelling of the upper wall of the meatus with headache and dizziness. To these belong especially those cases in which the handle of the hammer is adherent to the promontorial wall combined with a fistulous opening in the posterior superior quadrant of the membrana tympani, through which the crumbling septic pus flows from the attic, and which rarely heals without operative measures.

3. Cholesteatoma in the upper tympanic spaces, which is the cause of frequent relapses of middle-ear suppuration. The extraction of the hammer and incus has a favourable influence upon the suppuration in such cases, as the ossicula, on account of their position, form a hindrance to the removal of the cholesteatomous masses, and through the frequent occurrence of caries of the ossicula with cholesteatoma will continue the suppuration.

4. Chronic suppuration in the external attic with perforation of the membrana Shrapnelli. In this case the extraction of the hammer and eventually also of the incus should be carried out in persistent suppuration even where there is no visible caries of the hammer, if a large portion of the membrana tympani is destroyed and only a small remainder of the membrane is in connection with the hammer so that the hammer and incus are of no more value to the function of hearing. The extraction is also indicated in persistent septic suppuration discharging through the perforated membrana Shrapnelli with continuing severe deafness, without regard to the changes in the membrana tympani. On the other hand, I oppose the extraction of the ossicula in slight degrees of deafness, such as I have seen in the large majority of cases of perforation of the membrana Shrapnelli, with suppuration localized in the external attic. This contra-indication is based upon the pathological and anatomical fact that circumscribed caries on the hammer and incus may heal, and that the head of the hammer and the whole incus during long-continued middle-ear processes may completely disappear through carious degeneration. The latter

may be proved by clinical observation of cases in which, through suppurative destruction of the margo tymp. above the intact membrana tympani, a large opening exists at the inner end of the upper meatus wall which allows a free view of the upper tympanic space covered with smooth cicatricial tissue. One finds occasionally with the intact handle of the hammer no trace of the head of the hammer and of the incus which disappeared during the suppuration. I also found repeatedly in pathological preparations with opening in the membrana Shrapnelli and in the margo tymp. that are covered with epidermis, the suppuration healed in the external attic without any diseased change on the hammer and incus remaining. Owing to the possible danger to the hearing function, the extraction of the ossicula should only be done in urgent cases with threatening symptoms. Above all, excision of the remainder of the membrana tympani and the extraction of the hammer is indicated with dangerous symptoms of pus retention in the tympanic cavity, without considering the hearing function (Stacke).

5. With granulations in the upper tympanic space which repeatedly grow through the perforation in the membrana tympani if they are accompanied by retention of pus, headache and facial paresis, and in spite of the repeated removal and cauterization return anew.

In a young girl in whom during a middle-ear suppuration on the right side, accompanied by pain, pressure in the head, dizziness and facial paresis, masses of granulations grew out of the tympanic cavity, I succeeded in producing healing only after scraping out the tympanic cavity with a small sharp spoon and at the same time removing the hammer and incus. The hearing improved so much after the cessation of the suppuration that whispering could be understood at 12 metres.

6. After middle-ear suppuration has ceased, with severe disturbance in hearing owing to adherence of the handle of the hammer with the promontorial wall; in flat adhesions of the membrana tympani and handle of the hammer with the inner wall of the tympanic cavity; in extensive rigid calcification of the membrana tympani; in demonstrable anchylosis of the hammer and incus, and in incurable narrowing of the tube.

Operation.—There are two methods of extracting the ossicula.

(*a*) The intra-aural method. The intra-aural method consists in cutting around, loosening and extraction of the hammer, and eventually also the incus, through the external meatus without other operative procedures. The operation is carried out after previous antiseptic washing out and drying of the meatus with the patient in a sitting position. To anæsthetize the field of operation it is

generally sufficient to instil a cocaine solution (10 to 15 per cent.). It is only in unruly nervous patients that extraction under slight narcosis is advisable. If a large portion of the membrana tympani still remains this will be incised near the periphery with a small knife rounded at the end, and the hæmorrhage stopped by introducing a small pellet of iodoform gauze. The tensor tympani is then incised by means of Cholewa's tenotom (p. 316), and the connection of the upper end of the handle of the hammer with the margo tymp. and the Rivinian segment loosened by several semicircular cuts from left to right. After the hæmorrhage has ceased, if the hammer proves to be free, its extraction may be proceeded with. Schwartze removed the hammer by means of a Wilde snare. The instrument specially suited is Sexton's pincette (p. 324), with which the hammer is fastened in the region of the short process or at the neck, and is pulled downwards until the head of it is in the middle portion of the tympanic cavity, upon which it is removed.

The extraction after this method is very easy in many cases, and in others difficult, when the hammer is fastened to the incus by adhesions or masses of connective tissue, so that the handle of the hammer breaks off at the neck and the head remains in the attic. The latter also occurs in caries of the neck of the hammer and in rapid extraction without previous traction of the hammer downwards.

The extraction of the incus is much more difficult. Ludwig ascertained that through the extraction of the carious hammer alone the suppuration was only rarely stopped, as the more frequently carious incus still remains in the tympanic cavity. In seventy-five of Ludwig's operated cases the incus was carious sixty-four times, and the hammer scarcely in half of the cases. The isolated caries of the incus is therefore (also substantiated by Grunert) much more frequent than isolated caries of the hammer.

Considering that after the extraction of the hammer the function of the incus is removed, it is advisable to follow the extraction of the hammer every time by that of the incus, so as to produce a sure result.

As the long process of the incus is removed from sight in chronic middle-ear suppuration, owing to swelling and hypertrophy of the remainder of the membrana tympani and the mucous membrane of the tympanic cavity, or is entirely absent owing to carious degeneration, the extraction of the incus requires a manual dexterity which can only be acquired by previous experience on the cadaver.

The most suitable instrument for extraction of the incus is Ludwig's incus hook (Fig. 252), which bends at right angles to the shaft, and

measures 5 mm. long and 2 mm. in breadth. Even this instrument is not successful in all cases, as occasionally the attempt at extraction fails and the incus is dislocated towards the mastoid antrum.

Operation.—After the hammer has been extracted and the hæmorrhage stopped by tampons of iodoform gauze, the connection of the incus and stapes is cut through by a knife bent at right angles, as described on p. 316; the incus-hook should be introduced into the upper tympanic space beneath the Rivinian segment with the point directed upwards, and the hook should then be turned backwards and in a semicircle downwards, by which means the point of the hook fastens the incus at the saddle-shaped bend, and dislocates it into the lower tympanic space, from which position it is removed either by syringing or with the bent pincette.

Fig. 252.

Unfavourable accidents in extraction of the incus are severe dizziness, vomiting, headache and facial paralysis; the latter recovered in two of Ludwig's cases. The injury to the chorda tymp., which is not easy to prevent, is only followed by a temporary paralysis of taste.

The result of the extraction of the hammer and incus is occasionally exceedingly favourable in so far that suppuration which has existed for years ceases within a few days, and the hearing-distance increases to a varying degree. In other cases the suppuration continues owing to either disease of the bone in the tympanic cavity or in the mastoid process, and the operation has no beneficial influence upon the hearing-distance. In Ludwig's seventy-five cases, the suppuration ceased in forty-two cases operated upon, and the hearing-distance was improved in thirty-three cases. A decrease in hearing after the operation was only observed in a few cases; Reinhard had fifteen cases of healing in twenty-five operated cases.

As to the extraction of the stapes during and after the course of middle-ear suppuration there has previously been only reports of single cases. While Ludwig reports one case in which during the extraction of the hammer the stapes was accidentally extracted also, and complete deafness was observed, Jack reported several cases in which the operation was followed by remarkable improvement in hearing without the extension of the middle-ear suppuration to the labyrinth (*vide* Method of Operation, p. 320). The reports of Jack should be taken with great caution.

(*b*) Stacke's method.* This consists in loosening the auricle and cartilago-membranous meatus from its posterior insertion, and cutting away the external wall from the upper tympanic cavity with removal of the hammer and incus from the attic. This procedure is carried out by Stacke in persistent middle-ear suppuration, where, owing to the carious condition of the ossicula, their removal is indicated, and at the same time granulations, cholesteatomatous masses and carious portions of bone in the tympanic cavity may be removed.

The operative procedure is shortly as follows: after the incision round the auricle, immediately at its posterior and superior line of insertion, and separation of the periosteum, the hæmorrhage is stopped and the membranous wall of the meatus is loosened from the osseous wall so far that it remains in connection with the auricle in the form of a cylinder. Then the membranous meatus is cut across with a small scalpel immediately in front of the membrana tympani, from behind forwards, and the auricle, which is connected only with the soft portion in front of the ear, is pulled forwards and downwards by means of a retractor.

After carefully stopping the hæmorrhage the membrana tympani should be illuminated by direct daylight or bright artificial light, and an incision made around it, removing it together with the hammer. After this is done the inner portion of the upper wall of the meatus (external wall of the attic) and the posterior osseous ring of the membrana tympani is chiselled away until the upper tympanic cavity is completely opened, and no portion of bone is visible between the meatus and tympanic cavity. The incus is then extracted by means of a hook, and so much of the posterior wall of the meatus removed that the antrum appears to be in complete connection with the meatus. Through extensive curetting all diseased portions are carefully removed, the cavity being then well dried with iodoform gauze, and dusted with iodoform. The auricle and membranous meatus is then brought back to its former position, and the cavity of the wound and external meatus tamponed with iodoform gauze, and a bandage applied over the whole. The use of a suture is generally superfluous, and the only caution to be observed in the after treatment is that the communication between the antrum and meatus does not become stopped by granulations.

In thirty-three cases operated by this method, Stacke had nineteen cases of complete healing.

Where it is only necessary to extract the carious hammer and incus the less extensive intra-aural method is to be preferred, in my

* *Arch. f. Ohrenheilk.*, vol. xxxi.

opinion, a view which is also held by Schwartze, for the reason that the danger of an injury to the facial nerve is much more probable in Stacke's operation than in the intra-aural method. The opening of the attic as proposed by Stacke is only indicated when caries of both the ossicula and the walls of the tympanic cavity has been previously proved, or when after a successful or unsuccessful intra-aural extraction of the ossicula, a septic suppuration continues in the middle ear in spite of the local treatment, from which the probability of an accompanying caries of the walls of the tympanic cavity, and a septic suppuration in the mastoid antrum may be concluded.

Intra-cranial Diseases of Otitic Origin.

The intra-cranial diseases following suppuration of the middle ear occur :

a. When caries of the temporal bone extends to the cranial cavity ; thus :

1. By purulent meningitis, or by the formation of cerebral abscesses, the surface of the petrous bone, which is directed towards the cranial cavity, being fenestrated in one or more places, and the suppuration spreading to the meninges and the brain.

2. By septic phlebitis, thrombosis, embolism, and septicæmia, consequent upon the extension of the purulent process to the venous sinuses on the petrous bone, or the sinus of the jugular vein.

b. Without bursting of the suppuration into the cranial cavity.

By phlebitis of the cerebral sinuses ; more rarely by meningitis and cerebral abscess.

The Places of Carious Penetration of the Temporal Bone on the Base of the Skull.—The bursting of pus into the cranial cavity from the temporal bone, with consecutive meningitis and cerebral abscess, may occur in the following various sites at the base of the skull :

(*a*) On the tegmen tympani and on the roof of the antrum mastoideum. The roof of the tympanic cavity either exhibits one small perforation only, or is broken in several places like a sieve, or in the process of destruction an aperture with jagged, irregular edges is made, involving most of the tegmen tympani, by means of which the pus or cholesteatomatous masses (Burckhardt-Merian, Bezold) penetrate from the middle ear into the cranial cavity, or into the brain substance.

(*b*) On the posterior surface of the pyramid of the petrous bone. The suppuration in the bone advances from the tympanic cavity or the antrum mastoideum without injury to the capsule of the

labyrinth, passing through the pneumatic and diploëtic spaces of the petrous bone towards its posterior surface (Fig. 254), whereby the pus not unfrequently makes a way for itself through the petroso-mastoidean canal, which is not always obliterated (Voltolini).

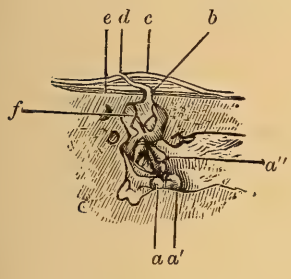

FIG. 253.—DIAGRAM OF A SECTION OF THE TYMPANIC CAVITY FROM A PATIENT WHO DIED OF A CEREBRAL ABSCESS DUE TO AN OTITIS.

a, *a'*, *a''*, Bulbous, pedunculated polypi growing out of the tympanic cavity into the auditory canal; *b*, Fissure in the tegmen tympani, 1½ mm. in size, without trace of caries in the vicinity; *c*, The dura mater adhering to the brain is lifted up like a tumour by the exudation; *d*, Sinus in the dura mater passing obliquely, the inner opening of which communicates directly with an abscess the size of a hen's egg in the temporal lobe. From a girl, 21 years of age, who had suffered since childhood from scarlatinal suppuration of the middle ear, and had for five weeks endured violent headaches, but had nevertheless been on her feet up to the day of her death. In the tenth week of her residence in the hospital, sudden rigors, temperature 40·2° C., general convulsions, inertia of the pupils, rigidity of the neck, eyes turned inwards and upwards, pulse thread-like and irregular, stupor, death in 7½ hours.

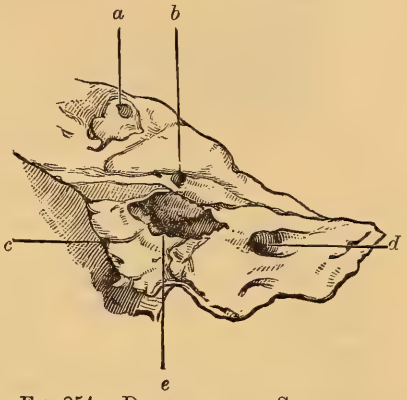

FIG. 254.—DIAGRAM OF THE SUPERIOR AND POSTERIOR SURFACE OF THE PETROUS BONE IN A PATIENT WHO DIED OF CEREBELLAR ABSCESS FROM AN OTITIS.

a, An irregular osseous defect in the tegmen tympani, 5 mm. in size; the bared mucous membrane with a pin-hole perforation, the dura mater at that point swollen and discoloured; *b*, Fenestra in the superficial petrosal sinus containing a thrombus; *c*, Necrosed aperture in the posterior surface of the pyramid in which the rough and uneven capsule of the labyrinth is visible; *d*, Meatus auditorius internus; *e*, Lateral sinus. In the left cerebellar hemisphere two abscesses, the size of a hazel-nut, communicating with the fissure in the petrous bone. The facial nerve swollen and infiltrated with pus. From a woman 36 years of age, scrofulous, affected for two years with otorrhœa of the ear, and suffering, when admitted, from violent occipital pain and left facial paralysis. Fourteen days after her admission repeated bilious vomiting and fever set in, this condition lasting for nine days. On the tenth day the patient lost consciousness, neck became rigid, left pupil contracted, and pulse thready; death on the following day without convulsions.

On the other hand, there are cases in which the capsule of the labyrinth is either partially destroyed or wholly stripped from the surrounding bone by an extensive ulceration (Fig. 254).

(*c*) Through the internal auditory meatus, when after erosion of

a semicircular canal (Fig. 255), of the vestibule, of the cochlea, or of one of the two fenestræ of the labyrinth (Schwartze), the cribriform lamina separating the internal auditory meatus from the labyrinth becomes fenestrated, and the pus reaches the base of the skull through the above meatus. In the same way, after erosion of the Fallopian canal, the suppuration may advance along the facial nerve to the internal auditory meatus, and thence to the base of the skull (Rotholz, *Z. f. O.*, Bd. xiv.). Suppuration rarely spreads from the labyrinth to the cranial cavity by means of the aqueductus vestibuli.

FIG. 255.—DIAGRAM OF THE INNER WALL OF THE TYMPANIC CAVITY FROM A TUBERCULAR PATIENT, 59 YEARS OF AGE, WHOSE DEATH HAD BEEN CAUSED BY PURULENT MENINGITIS.

a, Fenestra ovalis; *b*, Fenestra rotunda; *c*, Eroded horizontal semicircular canal through which, as well as through the two eroded apertures on the promontory *d*, the pus discharged into the cavity of the labyrinth and thence to the base of the skull. Purulent pachy- and lepto-meningitis. Destruction of the facial nerve. During life there was no perception of the tuning-fork from the vertex in the affected ear.

(*d*) On the inner side of the mastoid process, as after destruction of the osseous wall of the sinus lateralis, the suppuration extends to the membranous sinus. The dangerous symptoms produced by this, sinus phlebitis, thrombosis, embolism and pyæmia, will be more minutely described at the end of this section.

Sub-dural Abscess and Otitic Meningitis.

1. *Sub-dural Abscess.*

A disease of the dura of otitic origin which has only recently been properly described is the pachy-meningitis externa purulenta circumscripta. It is characterized anatomically by a collection of pus separating the dura from the pyramid of the temporal bone, so that an extra-dural or sub-dural abscess results. This form of disease, occurring especially in chronic middle-ear suppuration, complicated by caries, necrosis, and the formation of fenestræ in the temporal bone, when left to itself, produces a fatal result. The operative treatment of this disease is the production of a recent date.

The sub-dural abscess develops most frequently after carious perforation of the temporal bone, with the direct extension of the middle-ear suppuration to the dura mater; through periphlebitic extension of the inflammation from the diseased mastoid process; or, lastly, as a form of sub-periosteal abscess in

the acute infectious osteomyelitis due to microbic extension from the middle-ear suppuration to the endocranium.

The dura often withstands the destructive effect of the pus for a long time. In a phthisical patient whom I had examined during life I found post-mortem destruction of the membrana tympani, malleus and incus ejected, and in the tympanic cavity a sequestrum the size of a hazel-nut which had wandered from the mastoid process. The upper wall of the tympanic cavity showed two large defects in the bone over which the thickened mucous membrane was broken through. Corresponding to these places of perforation there was, on the external surface of the dura mater, an adherent mass of exudate, without there being any inflammatory change visible on the surface next to the pia mater.

The sub-dural abscess occurs more frequently in the middle fossa of the skull above the places of perforation on the tegmen tympani and the tegmen mast., less frequently in the posterior fossa in the region of the sinus transversus. Occasionally there are circumscribed or extensive thickened exudations corresponding to the purulently inflamed portions of bone which extend to the cranial cavity, without the formation of pus. In other cases the dura will be separated from the bone, to a varying extent, by the effusion of pus. The connection of sub-dural abscesses with the collection of pus in the tympanic cavity cannot always be found.

Symptoms and Diagnosis.—The symptoms of sub-dural abscess are rarely so characteristic that they offer a positive view for a precise diagnosis.

According to E. Hoffmann the existence of a sub-dural abscess should be considered probable when, with a positively proved disease of the temporal bone, and in spite of a complete opening of the mastoid process, a dangerous group of symptoms are present from meningeal irritation, fever and intense pain over the whole temporal bone, without being accompanied by pressure of the brain, or when accompanied by symptoms of meningitis or sinus phlebitis.

On the other hand, it should be noticed that the symptoms described are also present in lepto-meningitis and abscess of the brain, and that by the formation of solid masses of exudate on the external surface of the dura, symptoms of pressure may be produced. An important diagnostic symptom of extra-dural abscess, in my opinion, is the frequent changing appearance and disappearance of threatening symptoms, especially the cessation of severe inflammatory and meningeal irritation after a sudden free flow of secretion from the ear.

The sub-dural abscess goes on to perforation of the dura mater, and fatal result from basilar meningitis or abscess of the brain. Occasionally lepto-meningitis or abscess of the brain develops without perforation of the dura ex contiguo. Spontaneous healing of the inflammatory affected dura can occur after the expulsion or

extraction of a sequestrum from the tegmen tympani et mast., produced by ulceration of the bone, or by a cholesteatoma.

Treatment.—The only treatment in question is an operative removal of the collection of pus, which has been done within the last few years by Hoffmann, Körner, Hessler, Picqué, Hecke, Schwartze, and others, with good result. The operation is done according to the Küster-Bergmann method, after chiselling through the mastoid process, and eventually opening the tympanic cavity (*vide* Operative Opening of the Mastoid Process) as follows: one penetrates as far as the base of the skull with the chisel and hammer, enlarges the opening with Lüer's forceps, and empties the collection of pus; after carefully removing all diseased bone and granulation tissue, drainage is inserted, and an iodoform bandage applied. If there is no pulsatory movement of the brain at the portion of dura laid bare (a frequent symptom of abscess of the brain), an experimental puncture should be made with a Pravaz syringe to see if an abscess of the brain is present.

Sub-dural abscesses have been seen several times in connection with fistulous openings in the mastoid region. When dangerous symptoms appear the operative treatment is much easier, as the way to the intra-cranial collection of pus is indicated by the fistulous canals.

2. *Otitic Meningitis.*

Otitic meningitis develops either after ulcerative perforation of the dura or ex contiguo through inflammation transmitted from its outer surface.

The perforated dura mater appears in the region of the opening infiltrated, thickened by exudate or undermined by pus and separated from the bone. The perforation varies in size from the head of a pin to $1\frac{1}{2}$ cm. and over. In one case I found the dura perforated in several places corresponding to the sieve-like openings in the tegmen tympani.

The purulent lepto-meningitis is limited occasionally to a small area in the region of the ulcerated portion; more frequently, however, it spreads, to a varying extent, over the under surface of the brain, and may even extend over the convexity of the cerebrum and to the canal of the spinal cord.

The clinical picture of lepto-meningitis otitica varies much. The disease almost always begins with headaches, at first remitting and limited to isolated parts of the head, afterwards spreading over the whole head, increasing in violence and lasting without interruption.

At the beginning of the disease frequent accompaniments of the headache are persistent, bilious or mucous vomiting, great agitation, sleeplessness, loss of memory, and hyperæsthesia of the cutaneous nerves. With the further extension of the inflammation consciousness becomes more and more dulled, convulsions of the muscles of

the extremities and of the face make their appearance, more especially on the affected side, increasing to general convulsions either with or without convulsions of the neck and opisthotonos. The pupils are usually strongly contracted, reacting but little to light; abdomen retracted, the temperature variable, sometimes moderately high, sometimes again very high, more especially in meningitis affecting the convex surface of the brain. The frequency of the pulse, at the beginning almost always great, is at a later period diminished by the increase of the cerebral pressure, again to increase in the last stage of the disease. At the close paralyses occur—that is, either paralysis of the individual extremities or hemiplegia; the pupils dilate for the most part unequally; paralysis of the muscles of the bladder and of the rectum comes on; the respiration becomes hurried, the pulse small and frequent, and death follows on a comatose condition with symptoms of general paralysis. The combination of symptoms here described is by no means constant in every case, for frequently during its whole course a series of marked symptoms may be wanting, such as slowness of the pulse, etc.

Perforation of the tegmen tympani, in my experience, is usually accompanied by great tenderness on pressure over the temporal bone above the auricle. Several times I have seen a livid discoloration of the skin in this region, before the occurrence of a fatal result.

Course.—Its course is sometimes slow, sometimes very rapid. In its protracted forms the outbreak of the violent symptoms is often preceded for weeks or months by intermittent attacks of severe headache, and, later, by spasms in the muscles of the face, or facial paralysis. Even after the appearance of the above-named alarming phenomena, its progress may drag slowly up to the time of death, the vomiting, loss of consciousness, and convulsions may disappear again entirely, and the health be apparently normal for a longer or shorter period. Such paroxysmal attacks may often recur at greater intervals, until finally, after weeks or months, the illness terminates fatally with coma and general paralysis.

In other cases its course is short, especially in children, when meningitis supervenes in the course of acute purulent inflammation of the middle ear (Prout), sometimes also in chronic suppuration of the middle ear. I have seen cases in which the whole process up to death occupied only two or three days.

Result.—The result of otitic meningitis is almost without exception fatal. The possibility of recovery, however, is not excluded if the inflammation of the inner meninges has arisen without perforation of the dura mater. In such cases, by the occurrence of favourable local changes, such as the removal of a sequestrum or of decomposed

retention-products, the inflammation may be resolved, and recovery may take place. Anatomical changes of this nature may have existed in a series of those rare cases combined with otitic neuritis and cited in literature, as recovery from meningitis otitica. (Kippe, *Z. f. O.*, vol. viii.).

Diagnosis.—The diagnosis of otitic meningitis is often very difficult, more especially at the beginning. We have seen how in the case of children particularly, but also in the case of adults, well-marked symptoms of meningitis may be developed in consequence of the retention of pus in the course of acute as well as of chronic middle-ear suppurations, these symptoms quickly receding whenever the pus has made a way of escape for itself. It is only by the occurrence of paralysis of the muscles of the extremities and of the sphincter of the pupil, in conjunction with the other symptoms, especially with evidence at the same time of an optic neuritis and a hyperæmic engorgement of the retinal veins, that we are justified in diagnosing meningitis with great probability; yet in the later stage particularly, it may be easily confounded with cerebral abscess. Tubercular meningitis also developed in an individual suffering from suppuration of the middle ear, may, without direct connection with it, be taken for purulent otitic meningitis.

Prognosis.—The prognosis of meningitis otitica is unfavourable. Nevertheless, let the prognosis be cautious, for, especially at the beginning of the illness, decided meningeal symptoms may be produced by great hyperæmia of the brain, consequently without purulent inflammation. When the symptoms of compression of the brain become more markedly apparent, then only can a fatal issue be anticipated with great probability.

3. *Otitic Cerebral Abscess.*

This is developed either by continuity, by direct extension of the suppuration to the brain substance, or more frequently without direct connection with the pus-centre in the temporal bone. In the former case adhesion of the dura mater to the surface of the brain frequently takes place before the rupture in the neighbourhood of the ulcerated spot in the bone, thereby preventing the extension of the suppuration to the base of the brain, whilst the pus from the ruptured spot spreads directly to the brain substance. Frequently, however, adhesions of this sort are wanting. Indeed, cerebral abscesses have been often observed whose connection with the pus-centre in the temporal bone could not be proved (Thompson). Cases of cerebral abscess are very rare in which the membrana tympani is found intact (Schwartze), or in which every trace of ulceration in the bone is absent (Toynbee, *l. c.*; and Moos, *Virch. Arch.*, vol. xxxvi.). It is probable that in the last-named

cases the spread of inflammation from the pus-centre to the brain is brought about by the immigration of bacteria through the interstices of the connective tissue which accompany the anastomosing blood and lymphatic vessels of the middle ear and of the cranial cavity.

The otitic cerebral abscess usually develops as the result of chronic suppuration of the middle ear, very seldom in the course of acute purulent inflammation of the middle ear (Lebert, Farwick, Politzer), or from an injury when suppuration of the middle ear already exists (Roosa). According to Lebert, the otitic form constitute the fourth part of all cerebral abscesses, and according to v. Bergmann half of the deeply penetrating abscess (not including the metastatic) are of otitic origin.

In children under ten years, according to Körner, otitic brain abscesses are much more rare than at a later period of life. Abscess of the brain occurs twice as frequently among men as women.

The position of the brain abscess is, according to v. Bergmann,* always a typical one, either (1) in the temporal lobe, or (2) in the side of the cerebellum corresponding to the diseased side. In 100 cases cited by Körner 62 per cent. were located in the temporal lobe, 32 per cent. in the cerebellum, and 6 per cent. affected both portions.

A distinct relation between the localization of the cerebral abscess and the situation of the disease in different parts of the petrous bone, as believed by Toynbee, is not supported by Gull and Custer's observations (*Inaugural Dissertation*, 1879). On the whole, however, abscesses in the cerebrum are chiefly developed in ulceration of the tegmen tympani and upper surface of the pyramid; abscesses in the cerebellum, on the other hand, mostly in caries on the posterior surface of the pyramid, more rarely in affections of the mastoid process (Pomeroy). As a rule, the abscess is situated in the half of the brain corresponding to the affected ear; in exceptional cases, as in those of v. Tröltsch (*A. f. O.*, vol. iv.) and Magnus, in the other half of the brain, without connection with the seat of the disease.

The number and size of these abscesses vary much. Sometimes only one exists; at other times several connected, or quite isolated, pus-centres are found in the brain. Oftentimes a fistulous canal exists between the ulcerated spot in the dura mater and the abscess in the brain, thus affording direct communication between the pus centre in the temporal bone and the cerebral abscess, whose contents at times, under favourable conditions, may escape by the meatus.†

The cerebral abscess is, however, at times completely isolated and separated from the carious centre by a thin layer of normal brain substance. A cerebral abscess may vary in size from that of a pea to that of a goose's egg and upwards. Many abscesses reach such an extent that they engage almost the whole lobe of the cerebrum or cerebellum, their walls being formed only by a thin layer of the cortex of the brain. Older abscesses are sometimes surrounded by a connective-tissue capsule (Steinbrügge). Cerebral abscess is

* Surgical Treatment of Brain Abscess (*Arch. f. Klin. Chir.*, vol. xxvi.).

† Such cases were formerly erroneously explained as primary cerebral abscesses which had made an exit for themselves through the ear outwards—hence the term cerebral otorrhœa.

not unfrequently complicated (Gauderou, *Progr. med.*, 1876) with basilar meningitis and phlebitis of the venous sinuses (Wreden).

As regards the general frequency of brain abscess as compared to general middle-ear affections, we will consider Jansen's statistics for two and a half years in the Berlin ear clinic. Among 5,000 cases of middle-ear inflammation there were 7 cases of brain abscess. The mastoid process was always affected; in 4 cases the abscess was in the cerebellum, in 3 cases in the temporal lobe, 4 times on the right and 3 times on the left side. It was only found once among 2,650 cases of acute inflammation of the middle ear, with opening the mastoid process 149 times. The other 6 cases were comprised in 2,500 cases of chronic middle-ear suppuration, with chiselling of the mastoid process 206 times.

Symptoms.—The manifestations of otitic brain abscess vary according to its position and extent. According to v. Bergmann they may be classified in general in three groups as follows :

1. Symptoms of suppuration alone, separated from all other conditions. To these belong paroxysmal fever, chills, general dulness and depression, anorexia and disturbances of digestion, and especially an increase of temperature in the region of the diseased side of the skull, combined with circumscript tenderness on percussion (Toynbee, Ferrier-Horsley).

2. Symptoms of pressure, as headache, dizziness, unconsciousness, delirium, twitching and pareses in the extremities and muscles of the face, strabismus, disturbances in vision and speaking, retarded pulse, somnolence, Cheyne-Stoke's respiration, eclamptic attacks, with the peculiar characteristics of disappearance and return of the symptoms at times.

3. Symptoms of collections of pus are very rare in abscesses of the temporal lobe (inability to speak certain words, Ferrier-Horsley). When situated in the cerebellum they are often accompanied by dizziness and a staggering gait.

The course of cerebral abscess is very irregular, and in many cases latent, without marked brain symptoms. Alarming symptoms are developed sometimes months, sometimes weeks, before the fatal issue, seldom continuing however without interruptions, being rather paroxysmal in character with longer or shorter intervals. In other cases the severe cerebral symptoms are developed only a few hours before death.

The duration of abscess in the brain is likewise subject to great fluctuations, and sometimes cannot be determined on account of the slightly marked character of the symptoms. Cases in which the alarming symptoms ran a remarkably short course up to death, presented on dissection an old abscess surrounded by a connective-tissue capsule. The pathological changes in the neighbouring brain

substance in cases of multiple pus-centres indicate that these date from different periods.

The result of otitic brain disease is fatal when not relieved by operative treatment. Death results either from meningitis, after bursting of the abscess on the upper surface of the brain, or from encephalitis in the vicinity of the abscess, or from its rupture, and the discharge of its contents into the ventricle of the brain. Finally, the fatal issue may result from cerebral compression, from paralysis of the centres of respiration and circulation, from exhaustion, or from metastasis to other organs, especially the lungs.

Diagnosis.—The diagnosis of cerebral abscess is often very difficult because of its uncertain course and the indefinite combination of symptoms. In the latent stage frequently every diagnostic point is absent, whilst, on the other hand, upon the appearance of its violent symptoms it is often scarcely possible to distinguish it from meningitis. After the outbreak of the more violent cerebral symptoms, a probable diagnosis of abscess of the brain is therefore possible only when, for a considerable time, a constant unilateral or occipital pain has existed, accompanied by other symptoms of collections of pus.

Prognosis.—The prognosis of abscess of the brain until within a few years was absolutely bad, but since the operative opening has been inaugurated the prognosis has improved to a certain extent. In the extension of the operation, Dr. A. E. Barker, Drs. Thomas Barr and MacEwen of Glasgow, Profs. Bergmann, Schede and Truckenbrod have done great service.

The Surgical Opening of Otitic Abscesses of the Brain.

Indications.—The indications for this operation are given in the diagnostic symptoms previously described. Even in those cases where the collection of symptoms only makes the diagnosis of abscess of the brain probable, in view of the danger from the disease, the operation is positively indicated. The chances for the operation are the best when the diagnosis of brain abscess is made from long-continued headache localized in the parietal region (abscess of the temporal lobe) or in the the occiput (abscess of the cerebellum). Less favourable results are to be expected when more severe symptoms arise before doing the operation. That remarkable results may even then be obtained may be seen from the cases of healing after operated abscess of the brain reported. If from the symptoms the existence of an otitic abscess is diagnosed, the surgical opening of it must be immediately done, as this is the only way to save the patient.

Operation.—As regards the method of operation, there is complete unanimity upon all the principal points. When an abscess of the temporal lobe is diagnosed, the opening is made either by laying free the region of the temporal lobe above the external opening of the ear, or after opening the mastoid process. By the first method, according to the anatomical experiments of Chauvel, the skull should be opened between two lines placed in front and behind the auricle, and at right angles with a line from the angle of the eye to the top of the auricle. The place (*vide* Fig. 256, t) is $2\frac{1}{2}$ to 3 cm. above the external opening of the ear.* At this point an opening 3 cm. across is made with the chisel and hammer (MacEwen uses a trephine), and

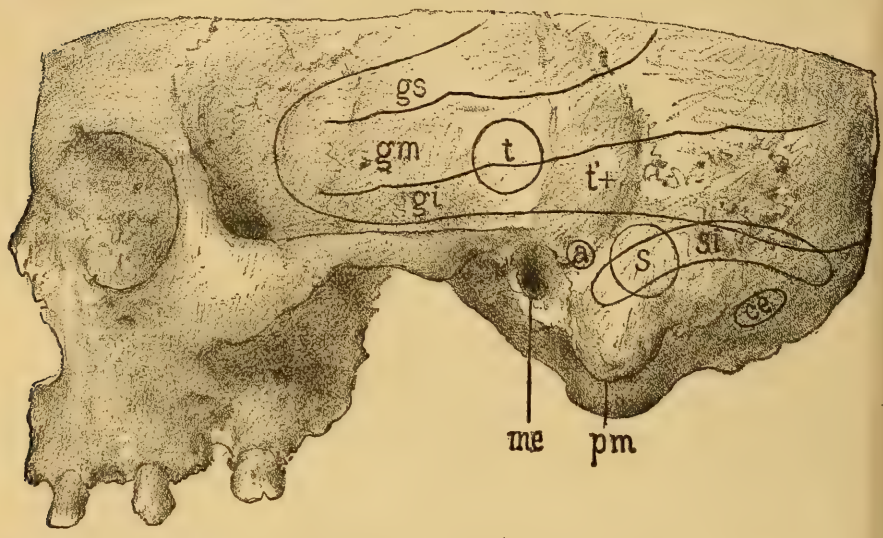

FIG. 256.—LATERAL VIEW OF THE SKULL WITH THE PLACES FOR INTRA-CRANIAL OPERATIONS INDICATED.

me, Meat. audit. ext.; *pm*, Proc. mastoid.; *gs*, *gm*, *gi*, The three gyri of the temporal lobe; *si*, Course of the transverse sinus; *t*, Place for trepanning the temporal lobe above the tegmen tymp.; *t'+*, Position of abscesses above the tegmen antrum mast.; *ce*, Place for opening an abscess of the cerebellum, between the sinus transversus and sinus occipitalis; *S*, Place for opening the transverse sinus; *a*, Place for opening the mastoid antrum.

the pulsatory movement of the brain observed. If pulsation is lacking it is probable that an abscess lies near that region; but the presence of pulsation does not preclude the existence of a deeply-seated abscess.

After finding the dura, an experimental puncture should be made to see if an abscess is present. The trocar has been discarded by most operators. On the other hand, the Pravaz syringe has always proved successful in the cases reported.

* The diagram given by Ballance (*Lancet*, 1890, No. 17) is subject to many corrections. Ballance remarked himself that the point of operation was not fixed, but varied according to variations in the skull.

After the experimental incision the dura is incised, and then, according to the custom of Bergmann, a pointed bistoury is slowly and cautiously inserted 4 to 5 cm. deep into the brain substance. If one does not come immediately upon pus it may be repeated in front and behind the first incision, as, according to the experiment of Bergmann upon animals, the simple incision even deeply into brain substance has no effect upon the function of the brain. Also in man the deep, penetrating stab wounds in the temporal lobe are not followed by bad results.

After opening the abscess often an ichorous pus mixed with gas will escape from the abscess cavity upon using drainage with slight pressure. Then a large drain is introduced, the cavity packed with iodoform gauze, and a bandage applied, which is changed at first daily, then once a week.

The procedure of opening the brain abscess after chiselling away the mastoid process is somewhat different. As in the majority of these severe cases the mastoid process is also carious or filled with a cholesteatomatous mass and the abscess is frequently directly above the tegmen antr. mastoid (Fig. 256 t′ +); this method is generally to be preferred.

After chiselling away the mastoid process (*vide* Opening the Mastoid Process), where abscess of the brain is suspected, the tegmen antr. mastoid is removed to the extent of 2 to 3 cm., and the dura laid free in the region of the posterior portion of the middle fossa. A collection of exudate upon the dura and a lack of pulsation of the tense dura mater is an indication for immediate experimental puncture, and when this gives a positive result the incision and opening of the abscess. When the puncture gives a negative result, one proceeds according to Küster's method (*vide* Opening of the Mastoid Process), and removes the tegmen tymp. forwards, avoiding the facial and semicircular canals, and makes an incision in the middle portion of the temporal lobe. Bandage and after treatment as in the first method.

In the operative treatment of cerebellar abscesses two methods may be used. One consists in chiselling away the mastoid process and penetrating from there into the posterior fossa, avoiding the sinus lateralis, and then opening the abscess. In the other, which according to my view gives more security, an opening is made 3 to 4 cm. in size, with a chisel or trephine at a point 4 to 5 cm. behind the insertion of the auricle in the occipital bone (Fig. 256, *ce*) between the sinus lateralis and sinus occipitalis. Two cases were operated upon by this method in Schwartze's clinic in whom the previous opening in the mastoid process had closed up.

As to the result of operation, it is probable that the cases which are cured are in the minority, as a number of fatal operation cases have not been published.

The fatal result may occur from different complications. As such may be mentioned: hæmorrhage from the middle meningeal artery,

extensive encephalitis or gangrene of the brain substance, prolapse of the brain, formation of abscess in other portions of the brain, meningitis, pyæmia, wound infection and general paralysis.

A favourable result is manifested after the operation by the quick return of consciousness and by the rapid or gradual disappearances of the previously-mentioned brain symptoms. In Baginsky's case euphoria occurred in a few hours; Barr's case of cerebellar abscess recovered consciousness within a few hours. The drained cavity of the abscess tamponed with iodoform gauze fills with granulations, in a regular course, and cicatrizes within 3 to 6 weeks. The middle-ear suppuration sometimes ceases with the cicatrization of the cranial wound, but may persistently continue, as I have frequently seen, after the operation.

The internal treatment of otitic meningitis and abscess of the brain is symptomatic. Cold cloths, icebags or Leiter's cold apparatus, internally the use of narcotics, subcutaneous morphine injections, to alleviate the severe headache; derivation from the intestinal canal (calomel), enemata in obstinate constipation, excitants (camphor, ether, wine) when depression commences, are the principal therapeutic adjuncts used.

Sinus-Phlebitis of Otitic Origin.

Among the venous sinuses traversing the temporal bone the most frequently affected is the transverse sinus to the inner side of the mastoid process; the superior petrosal and the cavernous sinuses, and, in destruction of the lower wall of the tympanic cavity, the bulbus ven. jugular. int. are more rarely involved.

An affection of the venous sinus is induced either by the direct contact of a carious or necrosed part of the temporal bone with the coat of the vein adjoining it, or not unfrequently without perceptible alteration in the state of the bone. In the former case there is discovered in the bone a defect of variable size, which communicates either with the cavity of the mastoid process or with the tympanic cavity by means of a fistulous canal in the posterior part of the pyramid. The neighbourhood of the necrosed portion of the sinus is often greatly softened and osteoporosed, while smooth or irregular osteophytes grow exuberantly on other parts.

That sinus-phlebitis may also occur without caries, through transmission from the mastoid process by the veins emptying into the sinus, or through septic ostitis of the sigmoid sinus with the retention of ichorous secretion in the mastoid process, I have already mentioned.

The changes in the venous wall vary much. When it comes into contact with the necrosed osseous wall it has the appearance of being thickened, brownish-yellow, or discoloured on its outer surface, or detached to a varied

extent by purulent or hæmorrhagic extravasation, or by greasy masses; lastly, ulcerated and perforated. The inner wall of the vein is likewise inflamed and tumefied, villous, or covered with firmly adherent layers of exudation, or destroyed. The lumen of the sinus contains a discoloured thrombus, solid or disintegrated, usually stationary, which sometimes stretches to the confluence of the sinuses on the one side, on the other in the jugular vein, as far as the subclavian. In this way phlebitis and thrombosis may extend from the transverse sinus to the superior and inferior petrosal sinuses, the cavernous sinus, and the emissary veins of Santorini (Orne Green, Chimani). Along with sinus-thrombosis, meningitis or cerebral abscess often occurs.

Carious destruction of the sigmoid sinus does not necessarily imply consecutive inflammation of the venous sinus itself. In one of my cases of caries of the mastoid process, with formation of sequestra and bursting externally, the osseous wall of the transverse sinus was deficient to the extent of 3 cm. in length and $1\frac{1}{2}$ cm. in breadth. The bare venous wall was covered with granulation tissue, the inner surface of the venous sinus being normal. In a case observed first in my clinic by J. Pollak a great part of the mastoid process with the furrow of the sigmoid sinus was exfoliated, without any affection of the venous sinus.

The formation of a thrombus in the lateral sinus is not absolutely fatal. When the coagulum is not septic, and when, after the formation of the thrombus, favourable local changes make their appearance in the neighbourhood of the lateral sinus, absorption of the coagulum, or transformation into connective tissue with obliteration of the sinus, may produce healing. Thrombi without septic character may exist for a long time without occasioning remarkable symptoms, as shown by the dissections of Eysell (*Arch. f. O.*, Bd. vii.), Fränkel (*Z. f. O.*, Bd. viii.), and Politzer.

Symptoms.—The most marked symptoms of sinus-phlebitis are severe chills, followed by an unusually high temperature (over 40° C., 104° F.). The frequent remissions, in which the temperature often sinks below the normal, and after a few hours with or without a chill rises to 39° to 40° C. or above, are characteristic for otitic septicæmia. There is always observed corresponding acceleration of the pulse; the skin becomes dry, and of a jaundiced colour after the illness has lasted some days; the tongue dry and coated, the head giddy, often painful, consciousness clear almost up to the last hour of life. Inconstant symptoms are vomiting, stiffness of the muscles of the neck and optic neuritis.

In many cases an œdematous swelling is developed in the mastoid region (Griesinger). In thrombosis in the internal jugular vein along its course a hard cord is felt, especially tender on pressure, and occasionally, after a certain period, such an œdema in the lateral region of the neck, that the almost simultaneous extension to the external jugular vein is thereby masked. In cases where from con-

tinuation of the thrombus into the bulbus venæ jugularis int., pressure is exercised upon the vagus, the glosso-pharyngeal, and the spinal accessory nerves in their passage through the jugular foramen, paralysis is produced in the area of these nerves (Beck, *Deutsche Klinik*, 1863).*

In extension of the thrombosis to the emissary veins, according to the observations of Orne Green (*American Journal of Otology*, vol. iii.), there occur painful infiltration and induration of the subcutaneous and subfacial connective tissue, reaching as far as the region of the neck. In like manner an advance of the thrombus from the jugular vein to the facial gives rise to œdema and erysipelas of the face and eyelids (Wreden).

Sinus-thrombosis presents a complicated combination of symptoms when the thrombus formation reaches the superior and inferior petrosal sinuses and the cavernous sinus. As symptoms of thrombosis in the superior petrosal sinus, the following have been cited: epistaxis, swelling of the veins extending from the anterior fontanelle to the temples, and epileptiform attacks. In one of my cases of erosion and thrombosis of the superior petrosal sinus none of those symptoms existed. The presence of a thrombus in the cavernous sinus leads to the formation of coagula in the ophthalmic veins, engorgement of the orbital vessels, disturbances of vision, photophobia, paralysis of the oculomotor and abducent nerves, exophthalmus, ptosis, œdema of the eyelids, or to sloughing of the orbital tissues.

The symptoms are so characteristic that diagnosis of thrombosis of the sinus-cavernosus can be made with certainty (Chimani, Burckhardt-Merian, Politzer, Wiethe).

Course and Result.—Sinus-thrombosis runs a very irregular course. The process is sometimes rapid, as when within a few days death occurs with symptoms of collapse, or by metastasis to vital organs; and sometimes so slow that long intervals of apparently normal health follow several chills, until at last, after the lapse of several weeks or months, the patient succumbs to pyæmia.

The result of secondary sinus-phlebitis is with few exceptions fatal. Death most commonly results from metastasis, especially by embolic pleuro-pneumonia, or gangrene of the lungs, less frequently by abscess of the liver, nephritis, or metastasis in the subcutaneous connective tissue and in the joints. But in isolated cases the fatal issue is brought about without metastasis by means of the paralyzing influence of the pyæmic blood upon the nervous system, or by the height of the fever.

* Hawkins' *Diagnosis and Treatment of Pyæmic Complications of Ear Disease.* St. Thom. Hosp. Rep., vol. xvi.

Recovery is very rare. The proof of such a result is indeed difficult, for the existence of sinus-thrombosis can by no means be affirmed with certainty, in spite of shiverings, high fever, and even pain along the corresponding jugular vein, without definite evidence of the formation of a thrombus there. Even cases such as that described by Prescott Hewett (*Lancet*, 1861), in which, besides the symptoms above described, metastasis occurred in the joints and in the lungs, cannot be regarded as conclusively indicating recovery from sinus-thrombosis, for a similar combination of symptoms may also be produced, without affection of the sinus, by the direct reception of septic material into the circulation from the cavities in the temporal bone. The same may be said of the case described by Sédillot. Wreden records a case of recovery from sinus-thrombosis, in which the symptoms of thrombosis of the transverse sinus, of the internal jugular vein and of the cavernous sinus were clearly marked.

Diagnosis.—Thrombosis of the lateral sinus may be diagnosed with probability when a highly febrile temperature follows upon repeated chills, with occasional remissions below the normal temperature. The diagnosis is absolutely certain only when proof exists of the presence of a solid thrombus in the jugular vein. There is danger of confounding it with meningitis and cerebral abscess only in the case of the simultaneous appearance of the sinus affection with these brain diseases. When such is not the case the differential diagnosis is all the easier, as the groups of symptoms characterizing both forms of disease present many divergencies. Whilst in meningitis and cerebral abscess there are neither such severe rigors nor such high temperatures as in sinus-thrombosis, in the latter we find the brain symptoms only slightly marked, consciousness often remaining unimpaired even up to the end.

Prognosis.—The prognosis of otitic sinus diseases was very unfavourable until within a short time, but owing to the great progress of modern surgery it has proved more favourable in so far, that results have been obtained by the operative treatment which were scarcely anticipated a few years ago.

Operative Treatment of Thrombosis of the Transverse Sinus.

Operative opening of the transverse sinus is much simpler and surer than the opening of intra-cranial abscesses, and I am certain that the sinus operation offers a much more favourable result than the opening of an abscess of the brain.

The operation is carried out as follows: after chiselling away the mastoid process (*vide* Opening the Mastoid Process), and carefully removing all diseased portions, the sinus is carefully laid free (Fig. 256, *s*). After this is done one should examine to see if the

wall of the vein has the normal dark-blue colour, or if it is inflamed, thickened, covered with exudate, whether it pulsates or not, and whether it is soft or hard to the touch. Want of pulsation and resistance leads one to think of thrombus. Fluctuation, with want of pulsation, should lead one to think of purulent or sanious degeneration of the thrombus. In order to be certain as to the character of the contents of the sinus, it is well to make an experimental puncture with a Pravaz's syringe.

In order to open the sinus, according to the suggestion of Lane, the lateral wall is incised in a vertical direction with a pointed bistoury, and the incision widened as necessary with a small pair of scissors. If the sinus is filled with a thrombus, this is removed with a pincette and curette, wiped out with iodoform gauze, and lastly irrigated with sublimate solution (1 in 1,000).

The chances for the operation are the best when the thrombus is limited to the sinus, and if the carrying away of the purulent mass is prevented by thrombosis above and below the degenerated portion.

The operation will be more complicated if the thrombosis extends into the jugular vein. In such cases the jugular vein should be laid open, according to the method of Rushton Parker, by means of a longitudinal incision in the skin, the thrombosed portion resected, and the ligature applied to the non-affected portion. Then the mastoid process, and finally the mastoid sinus, should be opened, the thrombus removed, the lateral inflamed walls of the sinus cut off with the scissors, then the sinus irrigated and dressed with iodoform gauze. The hæmorrhage which occurs during the operation from the transverse sinus may be stopped by iodoform tampons.

The internal treatment of sinus thrombosis accompanied by pyæmia, consists in the administration of large doses of quinine, salicylate of soda (2 to 3 grm. per day), antipyrine (0·5 to 1 grm. per dose). At the same time the strength of the patient should be kept up as much as possible by a nourishing diet (milk, eggs, roast meats), and stimulants: port wine, Madeira, Bordeaux, and brandy.

Fatal Hæmorrhage in consequence of Erosion of the Internal Carotid Artery.

A fatal issue to suppuration of the middle ear from bleeding from the eroded internal carotid artery may be reckoned amongst the rarest of results. Hessler (*A. f. O.*, vol. xviii.) has the merit of having collected the cases scattered through medical literature, and of having by his critical remarks given them value. Including the cases reported by Hessler, Moos, and Steinbrügge,

Sutphen and Politzer, there have been reported in all 16 cases in which the diagnosis of erosion of the internal carotid has been shown and proved by dissection. My case of erosion of the carotid with a fatal result affected a phthisical individual aged 32 years.

Anatomy.—In every case the portion of the carotid canal adjoining the tympanic cavity was carious and defective to a varied extent. The destruction was commonly associated with spreading caries in the temporal bone, and the osseous gap in the carotid canal was either free, or still occluded with sequestra. The aperture in the generally softened arterial wall was always found at the spot where the course of the vessel passed from the vertical to the horizontal direction. Only in two cases observed by Baizeau (*Gaz. des Hôp.*, 1861, 88) and Choyau (*Arch. gén. de Méd.*, 1866) was the carotid perforated in two places; in all the other cases there was a fissure in the arterial wall of 3 to 8 mm. in length and 2 to 6 mm. in breadth, its edges being either serrated and fringed, or more rarely as if incised (Grossmann, *Casuist. Beitr. z. Ophth. und Otiatr.*, Pesth, 1879). In my case there was a sharply cut oval opening in the carotid canal, with an opening even larger in the eroded artery corresponding to it. A direct communication between the tympanic cavity and the eroded artery could be proved in every case. In the case described by Busch and Santesson (*Schmidt'sche Jahrb.*, 1862), the transverse sinus was also simultaneously eroded. In every case, the blood poured forth through the perforated membrana tympani into the external meatus, but in Pilz's case the membrana tympani was intact, and the blood escaped by a fistulous aperture in the lower wall of the meatus, leading to an abscess-cavity involving the anterior portion of the petrous bone, and opening by another fistulous aperture upon the upper wall of the pharynx.

As regards complications, tuberculosis existed in seven cases, scrofula in one, secondary syphilis in one (Pilz, *Dissert. inaug.*, Berlin, 1865), and in one case the cause of the suppuration of the middle ear was said to be corrosion with concentrated acids (Sokolowsky, *Centralbl. f. Chir.*, 1881).

In several cases the erosion of the carotid was complicated with circumscribed pachymeningitis, with basilar meningitis, meningitis of the upper surface of the brain, and with cerebral abscess.

Regarding the commencement of erosion of the carotid, it must be accepted as beyond doubt that in most cases the inflammatory softening of the arterial wall, by its being bathed in pus and ichor, so diminishes its power of resistance that the repeated shock of the blood-wave against it finally produces an aperture in the arterial wall. In rarer instances, the aperture may be produced by the wearing pressure of a sequestrum against it.

The duration of the ear-disease up to the commencement of the bleeding varied between seven and eleven years. In two cases only is the suppuration said to have lasted but several months; and in the case of syphilis observed by Pilz, it is stated to have appeared in the course of an acute caries.

Symptoms.—The discharge of blood from the ear in the majority of cases is profuse, but not always in spouts. In some cases a continuous oozing only was observed, whilst in four instances the stream of blood burst with such force from the ear that it formed a

jet as thick as the little finger (Chassaignac, *Traité de la Suppuration*), or that the plug was ejected from the meatus (Broca, Hermann). The amount of blood lost in a more violent bleeding varied from 240 to 1,500 grm. The blood is generally bright red, seldom mixed with pus. Sometimes the blood escapes at the same time through the Eustachian tube into the naso-pharynx. Pain during the bleeding was seen in only one case. On the other hand, especially in the case of profuse hæmorrhage, anæmia, with fainting-fits and collapse, was rapidly induced.

The number of hæmorrhages before the fatal issue varied in the thirteen cases from one (Hessler) to three, four, seven, and even twenty (Toynbee, *Diseases of the Ear*, 1860).

The duration of each attack of hæmorrhage varies from four to ten minutes (Prescott Hewett, *Arch. gén. de Méd.*, xiv., 1837); in one case it was seven hours (Broca-Jolly, *Arch. de Méd.*, 1866); and in another six days with barely twenty-four hours' intermission (Hermann, *Wien. med. Wochenschr.*, 1867). The period from the commencement of the first hæmorrhage till the fatal issue, if the three cases are excluded in which the carotid was ligatured, varied from five minutes to thirteen days. In the cases operated upon, death occurred in one in three days, in another in four weeks, and in Pilz's case (erosion of the right carotid), operated upon by Billroth, seventeen days after ligature of the right and three days after ligature of the left carotid.

In every case the result was fatal; three times from profuse hæmorrhage, and in the remaining cases from exhaustion or pulmonary phthisis (Broca).

The diagnosis depends on the bright red colour of the arterial blood, and the cessation of the hæmorrhage on compression of the carotid. It must be accepted as certain that the bleeding proceeds from the carotid when the blood spurts from the ear in great gushes with each systole of the heart. Should the bleeding not be very violent, it might be inferred that there was erosion of the middle meningeal artery (Ward, *Transact. of the Pathol. Soc.*, 1846), or of some other small branch of the carotid. Bleeding from the lateral sinus may be distinguished from carotid hæmorrhage by the fact that in the former the blood-stream is dark red, and continues after compression of the carotid.

The *prognosis*, as far as experience has yet shown, is absolutely unfavourable.

Treatment.—In the case of every aural hæmorrhage which arouses suspicion of erosion of the carotid, an endeavour must in the first place be made to stop the bleeding by means of compression of the common carotid. This, however, can only be of service when it is

carried out immediately, and for a considerable time. It is of importance to teach someone in attendance upon the patient how compression is to be applied, so that, in the event of a recurrence of the bleeding before the return of the physician, much loss of blood may be avoided.

Should the compression be insufficient or impossible on account of the extreme pain which it causes (Toynbee), then ligature of the common carotid must be tried. In one of the cases operated upon, in which nine days after ligature hæmorrhage from the ear, mouth, and nose recurred, ligature of the other carotid had to be resorted to; but three days later death occurred during an attack of bleeding. Although among the small number of cases hitherto observed the operation has never proved successful, this by no means precludes the possibility of a successful issue in future operations, should the local changes in the vicinity of the eroded carotid prove to be more favourable, and the obliteration of the carotid, which has been obstructed by a ligature thrombus, be rendered possible. Whether in the case described by Denucé (*Bull. de l'Acad.*, 1878) of recovery from an arterial hæmorrhage from the ear by the use of ligature of the carotid, the cause of the bleeding was erosion of the internal carotid, must remain undecided. For the details of the operation, reference must be made to the large manuals of surgery.

Plugging the external meatus, preventing as it does for the moment the rapid gush of the blood, has proved useless, as the blood speedily makes a way for itself through the Eustachian tube into the naso-pharynx. Just as little benefit may be looked for from the use of injections of solutions of chloride of zinc and of iron, from the application of cold, and from the internal administration of ergot of rye and gallic acid.

The Diseases of the Mastoid Process, with Special Consideration to the Operative Opening of it.

A. Primary Acute Inflammation of the External Mastoid Region (Periostitis Mastoidea).

Primary diseases of the mastoid process without simultaneous affection of some other portion of the organ of hearing are, on the whole, rare. Inflammation begins either on the external periosteal covering (periostit. mast.), or in the internal cell-spaces of the mastoid processes (ostit. mast.).

Primary periostit. mast. is extremely rare, and is oftener observed in adults than in children. It usually occurs after catching cold, or after trauma, but sometimes without any traceable cause. In a

case observed by me, the source was a phlegmon on the left cheek, which wandered from here above the auricle to the mastoid process, and ended as a large periosteal abscess. The inflammation affects either a limited part of the periosteum or spreads over the whole mastoid region, even to the temple. It is characterized by the formation of a hard, usually red swelling on the mastoid process, which becomes ill-defined towards its margins, and is painful on pressure. Sometimes the superior portion of the sternocleido-mastoid muscle is (Knapp) involved in the inflammatory process. With the exception of an occasional slight reddening on the posterior wall of the auditory meatus, no inflammatory symptoms are to be found on the membrana tympani and in the meatus.

The most prominent subjective symptom is violent pain in the inflamed area, which radiates in various directions over the head, and is increased by movement of the head or slight pressure. The temperature of the skin in that region is increased, the hearing function normal, and only rarely diminished by old adhesive processes in the middle ear. The accompanying pyrexia is usually moderate, but may reach a high degree if abscesses form.

The course and termination of primary periostitis mastoidea are generally as follows: The inflammation reaches its acme after some days, and the infiltration subsides without suppuration, or, as in the cases observed by Roosa and Ely (*Z. f. O.*, vol. ix.), Webster (*Arch. of Ot.*, viii.), and Knapp, an abscess forms and recovery ensues after spontaneous rupture, or after opening of the abscess, or the pus finds its way into the external auditory meatus, one of the incisuræ Santorini or the membranous part of the cartilaginous portion being broken through, as has been observed by Swan Burnett (*Z. f. O.*, vol. ix.), Hotz, and myself.

Sometimes the inflammation progresses to superficial painless necrosis of the corticalis (Politzer) with casting-off of several splinters of bone (Hotz). I have repeatedly seen in children the formation of such isolated abscesses on the external surface of the mastoid process which probably resulted from the transmission of the inflammation from within the mastoid process by means of the lymph vessels through the corticalis or by extension from the external meatus. They develop very rapidly and frequently break through the cartilago-membranous portion of the external meatus when the pus is not previously removed by an incision. In either case healing quickly follows by adhesion of the abscess walls, especially if the proper pressure bandage is applied.

The diagnosis depends on the objective changes on the mastoid process, taken together with the absence of inflammatory pheno-

mena in other portions of the temporal bone. In long continuance of the infiltration and pain, even with an intact membrana tympani, the possibility of a secondary affection from inflammation of the external periosteum extending to the interior of the mastoid process cannot be excluded. It is possible by a superficial examination to confound this with those painful swellings on the mastoid process, which sometimes exist in cases of deep-seated furuncles on the posterior wall of the auditory meatus or in primary inflammation and suppuration of the lymphatic gland lying on the mastoid process.

The prognosis of primary periostitis mastoidea is favourable.

Treatment consists in the use of energetic antiphlogistics (Leiter's cold apparatus, application of tinct. of iodine or unguent. ciner.); and if, after two or three days, the inflammatory symptoms do not subside, an incision must be made in the swelling down to the periosteum. Where the exudate has not already broken down into pus healing often occurs without its formation. When there is an abscess, the pus must be evacuated by a sufficiently deep incision.

The secondary periostitis mastoidea which arises from extension of inflammation or caries from the interior of the mastoid process, or from the walls of the external meatus, will be discussed along with the terminations of ostitis mastoidea.

B. Inflammation of the Cell-spaces of the Mastoid Process (Ostitis Mastoidea).

The inflammatory processes which affect the muco-periosteal lining of the pneumatic spaces of the mastoid process seldom arise primarily, but usually by extension of inflammation from the tympanic cavity, more rarely from the external meatus.

(a) Primary Acute Inflammation of the Mastoid Cells.

Primary inflammation of the lining of the mastoid cells appears either spontaneously without any known cause, or from the effects of cold, injury, or syphilis. Occasionally it develops in the course of a serous or mucous catarrh (Walb, Körner), or, as I repeatedly saw during the influenza epidemic, after an acute middle-ear suppuration.

There is no doubt that in primary ostit. mast. we have to do usually with a bacterial infection from the naso-pharynx. In this case the microbes in the tympanic cavity may lose their vitality, while those in the mastoid process may increase in virulence owing to favourable conditions for development. The diplococcus of pneumonia is most frequently found in acute

mastoid abscess (Scheibe). That in influenza abscess a specific micro-organism causes the affection is proved by the destructive character of the pus in those abscesses.

The primary ostitis mast. nearly always affects only the pneumatic spaces of the mastoid process. The most frequent seat is the terminal cells in the posterior portion of the mastoid process, yet a greater part of it may be affected by inflammation and abscess formation.

Symptoms.—Primary ostitis mastoidea begins with slight pain in the region of the mastoid, which after a time becomes stinging, tearing, and throbbing, without redness or swelling of the integuments. After several days in intense inflammation or when it nears the surface, there is a feeling of pressure on the external surface and at the apex of the mastoid, and in consequence of secondary periostitis mastoidea, there is a painful swelling in the soft parts over that process. The formation of abscess in the mastoid process usually occurs with high fever and increased pain. When the abscess is peripherally situated it perforates through the carious softened corticalis or through the fissura mast. squamos. (Kirchner, Kiesselbach) with the formation of a fluctuating, sub-periosteal abscess in the mastoid region. Occasionally a sub-periosteal abscess develops through the means of the blood and lymph vessels without direct connection with the pus collection within the mastoid process.

Course.—The course of primary ostitis mastoidea is very short in the genuine cases, as after six or eight days the acme of the inflammation is reached and healing without abscess formation takes place, or it ends in suppuration and external rupture after three to six weeks. In spontaneous perforation a fistulous suppurating cavity in the mastoid process may remain until the fistula is enlarged and the cavity scraped out with a sharp spoon, after which it fills with granulation tissue and healing occurs. On the other hand, the traumatic and syphilitic inflammations which end in caries have a long and uncertain course, as also those forms in which the inflammation spreads to the tympanic cavity and the membrana tympani becomes perforated. Very rarely perforation of the abscess occurs on the median wall.

Diagnosis.—The diagnosis of primary ostitis mastoidea depends on the persistent pain in the interior of the bone, and on the late appearance of swellings on the mastoid process and in its neighbourhood. Characteristic of primary ostitis mast. is the failure of reactive inflammatory symptoms in the tympanic cavity during the development of symptoms pointing to formation of abscess in the mastoid process. The diagnosis is, however, impossible if, at the

time of the first examination, great infiltration or an abscess already exists on the mastoid process, as these also occur in primary periostitis mastoidea. If in such a case after Wilde's incision (see below), or after discharge of an external abscess, the pains in the mastoid process remain unabated, then only may we suspect a deeply situated abscess in the bone. Also after the inflammation has extended to the tympanic cavity, it is not possible to determine whether the case in question is one of primary or of secondary inflammation of the mastoid process.

Prognosis.—The prognosis of mastoid ostitis is favourable in the uncomplicated forms and when the abscess is situated superficially. It is less favourable in cachectic and syphilitic individuals and also when the abscess is deeply seated, on account of the possibility of the suppuration extending to the venous sinus.

Treatment.—The treatment of primary mastoid ostitis is similar to that of secondary mastoid ostitis. For the antiphlogistic measures, Wilde's incision and opening of the mastoid process, I would refer to the following section.

Previously in the text-books the secondary acute inflammations of the mastoid cells have been described together with the disease processes occurring during chronic middle-ear suppuration. In consideration of the differences in their development, their clinical course, and especially the different methods of operation suitable for each form, I determined to describe separately the acute and chronic forms of disease of the mastoid process.

(*b*) *Inflammation of the Mastoid Cells during the course of Acute Middle-Ear Suppuration.*

The inflammation of the mastoid cells occurring during the course of an acute middle-ear suppuration, develops through the extension of the inflammation from the tympanic cavity to the covering of the cells. As etiological factors may be mentioned : catching cold, getting wet, injection of large quantities of fluid into the middle ear, general and infectious diseases such as typhus, scarlatinous diphtheria, tuberculosis and syphilis. The formation of abscesses occurs especially frequently during the course of influenza-otitis.

The pneumatic mastoid process is more frequently affected by the inflammation, and the diploëtic mastoid process much less frequently. Inflammation and abscess-formation do not occur in the vertical portion of compact mastoid processes.

With every acute middle-ear suppuration pus is found in the cells of the mastoid process, as I have proved by numerous dissections. This is explained, if one considers that in every suppuration in the

cavum tympani, when the patient lies on his back, the pus flows into the mastoid antrum and cells. The presence of pus in the antrum and mastoid cells does not imply, therefore, an inflammation or abscess-formation in the mastoid process, as acute otitis frequently runs its course without reactionary symptoms in the mastoid process. One should, therefore, only speak of an inflammation of the mastoid cells when, owing to micro-parasitic infection, the lining membrane of the cells is itself inflamed, and at the same time the osseous structure of the mastoid process is affected with inflammatory symptoms.

An important cause of the secondary inflammation and abscess-formation is to be found, according to my view, in the peculiar anatomical varieties of the pneumatic mastoid process. While in many cases an extensive communication exists between the antrum and cells, in others the communication is so narrow that only the smallest needle can be passed through. Occasionally the whole mastoid process consists of one or two large cavities containing air, at the upper portion of which is a canal communicating with the antrum, scarcely large enough for the passage of a bristle. So long as the cellular cavities communicate with the antrum and no stagnation of the secretion in the mastoid process occurs, the formation of an abscess occurs very rarely. If, on the other hand, the small opening between the antrum and cells should be closed by swelling or exudation, and the pus separated in the cell cavities, inflammation of the osseous tissue may be produced by this means alone. That the formation of osseous abscesses in the mastoid process during typhus, scarlet fever, diphtheria, influenza, and tuberculosis, is largely due to the destructive character of the infectious secretion, cannot be doubted from the clinical observation.

Symptoms.—The appearances of acute inflammation of the mastoid cells vary according to the stage in which the patient comes under observation. Otitis media acuta running its course without perforation of the membrana tympani is often accompanied by symptoms of irritation in the mastoid process which usually subside. In acute purulent middle-ear affections, symptoms of inflammation in the mastoid process develop either before or after perforation takes place. In either case spontaneous pain occurs in the mastoid process, besides the pain which radiates from the ear in all directions. This is accompanied by tenderness on pressure and percussion at its tip and middle portion, and with increased temperature of the external integument covering the process. The temperature of the body varies from 37° to 39° C., and occasionally reaches 40° C. in extensive abscess-formation.

The symptoms of reaction in the mastoid process accompanying acute suppurative middle-ear inflammation may disappear spontaneously, or with appropriate antiphlogistic treatment after repeated remissions and exacerbations. This result is most frequently

observed in simple acute middle-ear suppuration. Abscess-formation in the mastoid process is very much more frequent with influenza-otitis, and with the middle-ear suppuration occurring during the infectious diseases. This is of special interest to the practitioner, owing to the dangerous complications following it.

Abscesses in the mastoid process occurring during acute suppurative middle-ear inflammation have, with few exceptions, their location in the middle and lower part of the vertical portion of the mastoid process, lying next to the corticalis.

Usually there is only one abscess cavity, but there may be several, separated from one another. These may unite during the further course of the disease. According to my observations the abscess is isolated almost without exception, and has no communication with the mastoid antrum.

The symptoms of acute abscess in the mastoid process are: 1. Pain in the mastoid process, without remission, which is increased by pressure and percussion. After the abscess becomes localized the pain usually remains fixed at one point. Usually the tender portion corresponds to the location of the abscess within the mastoid process, although that is not constant. In exceptional cases, extensive abscess formation in the mastoid process may occur without pain or tenderness, as I observed in a woman who died from abscess of the brain following influenza-otitis. 2. Exceptional increase of temperature on the mastoid process in comparison with the healthy side. 3. The membrana tympani appears strongly bulged forward before the pus perforates; following perforation a round or nipple-like projection is often found in the posterior superior quadrant of the membrane, on the tip of which the perforation is situated. 4. A depression of the posterior superior wall of the meatus with narrowing of its lumen. I place great importance on this appearance as an indication of abscess in the mastoid process. 5. Profuse discharge of pus from the ear. Only once have I seen the suppuration in the tympanic cavity cease while the symptoms of inflammation in the mastoid process continued undiminished.

Course.—The symptoms of inflammation with abscess-formation in the mastoid process may continue several weeks, the pain remitting, and the temperature showing great variations. A profuse discharge of pus from the ear signifies a continuance and extension of the abscess-formation, while a decrease of the discharge, with an accompanying diminution of the pain, allows one to conclude as to the healing of the inflammation. Occasionally cases are observed in which, several days after the local symptoms disappear, abscess-

formation in the mastoid process is manifested by such severe symptoms that operative treatment must be proceeded with at once.

Results.—The results of mastoid ostitis are: 1. Healing through the disappearance of the inflammatory changes in the osseous tissue without the formation of pus. 2. Abscess-formation. This may heal spontaneously, especially in the genuine forms of otitis, through the resorption of the contents of the abscess, or it may progress to 3. Carious destruction of the bone, as the separated pus has a destructive action on the surrounding osseous tissue. These changes develop very frequently in influenza-otitis through the effect of the specific excitant of the disease. The osseous tissue is softened and decayed, the abscess cavity is filled partly with pus, partly with bad-looking fungoid granulations, in which necrotic fragments of bone are imbedded. These changes are usually found after the abscess has existed for a long time, but occasionally are seen 10 to 14 days after the beginning of the disease. 4. Spontaneous perforation of the abscess through the external cortex. This occurs more frequently in children, and is followed by a tedious fistula, or by the exfoliation of a sequestra, and healing with a depressed cicatrix. Rarely the abscess perforates the posterior wall of the meatus, or on the median side of the mastoid process (Bezold). 5. Extension of the suppuration from the mastoid process to the cranial cavity, producing meningitis or abscess of the brain, or to the venous sinus, ending in fatal sinus-phlebitis.

Diagnosis.—The diagnosis of secondary inflammation and abscess-formation in the mastoid process is made from the connection of the previously described symptoms, and the course of the disease. It is most difficult at the beginning of the disease, as pain and tenderness on the mastoid process in acute middle-ear suppuration may be produced by severe congestion of the covering of the mastoid cells and osseous tissue, which disappears in a short time. The diagnosis of abscess is almost positive if the pain in the mastoid process continues several days with persistent fever, sleeplessness, and nervous irritation, profuse otorrhœa, and narrowing of the external meatus. If the patient first comes under observation with these symptoms after the otitis has lasted several weeks, there can be no question as to the presence of a mastoid abscess.

Prognosis.—The prognosis of secondary acute inflammation of the mastoid cells is on the whole more favourable in the simple form, or that following influenza or typhus than in the scarlatino-diphtheritic and tuberculous processes. Early therapeutic measures materially affect the prognosis of abscess formation in the mastoid process. The shorter the duration of the abscess the more limited

its extent, and the quicker and more surely healing will occur after opening it. The longer the duration of a mastoid abscess the more rapidly the destruction of the osseous tissue occurs around it, until a large portion of the mastoid cells are destroyed, and there is danger of its extension to the vital organs.

Treatment.—The treatment of acute mastoid ostitis depends upon the stage in which the patient comes under observation. If one has the opportunity to observe the patients during the first days of the disease, before perforation of the membrana tympani occurs, this appears strongly congested, swollen, and bulged outward; if there is at the same time spontaneous pain in the mastoid process, which is increased on pressure, paracentesis of the membrana tympani must be first done in order to allow the pus collected in the middle ear an opportunity to flow freely. This operation, which may be easily carried out by every practitioner, is sometimes sufficient to cause the inflammatory symptoms in the mastoid process to subside, after a free discharge of pus. Even when spontaneous perforation of the membrana tympani occurs, and the symptoms of inflammation in the mastoid process remain, it may be made to subside by energetic antiphlogistic treatment: the application of several leeches, Hourteloupe's artificial leech or Delstanche's aspirating syringe to the tender point, the continued application of cold by means of Leiter's apparatus (Fig. 257), the painting of the mastoid process with tincture of iodine, or rubbing with ung. ciner., and the injection of warm sterilized water through the catheter into the tympanic cavity (Millingen).

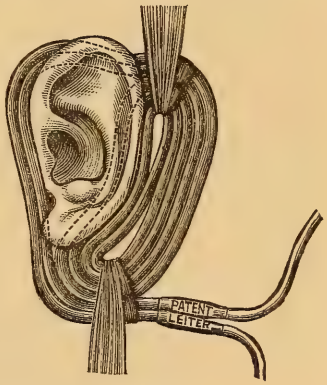

FIG. 257.

By means of the treatment here described, it is possible, especially in the simple form, to alleviate the inflammation in the mastoid process after 3 to 4 days, with an accompanying decrease of the fever temperature. The antiphlogistic treatment proves less efficient in inflammation of the mastoid cells, produced by scarlatina, tuberculosis, syphilis, and influenza. The early application of the Leiter apparatus serves to stop the abscess-formation during influenza in only a few cases.

The Leiter apparatus is well borne, owing to its effect in easing pain. It is of a certain diagnostic value, in so far as the continuation of the inflamma-

tion in the mastoid process may be concluded, so long as the apparatus is well borne and desired by the patient, while as soon as the effect of the cold irritates and is unpleasant to the patient, the disappearance of the inflammation is probable.

Indications for opening the Mastoid Process.—If the antiphlogistic treatment is without result after several days' application, if the profuse otorrhœal pain in the mastoid process and fever continues, and especially if the evening exacerbations of fever do not cease, or symptoms of meningeal irritation and vomiting or chills occur, opening of the mastoid process must be immediately done. The immediate carrying out of the operation is also indicated if it is proved by the history that the stormy symptoms signifying abscess-formation have lasted for more than ten days.

The question, whether we should operate early or treat the case expectantly, is decided as follows: Those cases which heal without operative interference speak for waiting. If it is remembered that the longer duration of the abscess may proceed to extensive destruction of the mastoid process, that the destruction extends deeply, and by long waiting we may be surprised by a sudden fatal termination, an early operative interference is indicated, bearing in mind that the operation is comparatively free from danger. The advantages which the early opening of the abscess offers consist essentially in its being still small, superficially situated and easily reached, that by scraping out the diseased portion it does not produce so much loss of substance in the bone as longer-continuing abscesses, that the more rapid healing and the whole middle-ear process with its severe symptoms is more rapidly recovered from, and the duration of treatment thereby very much shortened.

The opening of a mastoid abscess in acute middle-ear suppuration is, considering the dangerous complications which may be produced by the abscess itself, a vital indication. The operation is easily carried out, as the usually superficial abscess is easily opened without danger of injuring the more deeply-seated vital organs. It can therefore be carried out by every practising physician who is familiar with the principles of surgery.

The operative procedures for mastoid abscesses occurring during the course of acute middle-ear suppuration are quite different from opening the mastoid antrum in chronic middle-ear suppuration.

Instruments.—The instruments for opening the mastoid process which are also used for laying free the mastoid antrum, consist of the following pieces: One broad and one small scalpel, one pointed and one blunt bistoury, an anatomical pincette, several artery forceps, a sharp-edged elevator 8 mm. wide,

four gouges, 8, 6, 5, and $3\frac{1}{2}$ mm. wide (Figs. 258, 259, 260) a handy metal hammer with lead filling; three or four sharp spoons of varying sizes (Figs.

FIG. 258.

FIG. 259.

FIG. 260.

FIG. 261.

FIG. 262.

261 and 262); one straight and one Luer's bent forceps; several sharp and blunt hooks; a strong dressing forceps to fasten and pull out loosened sequestra; grooved director and blunt sounds, ligatures and curved needles; Barth's

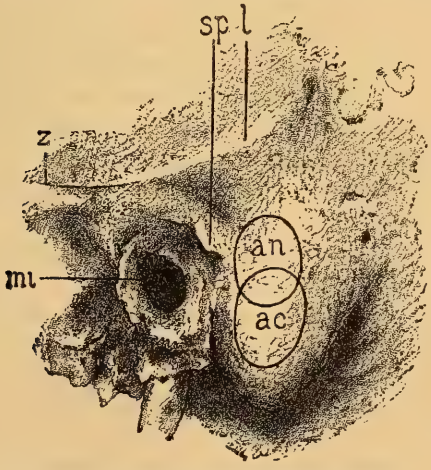

FIG. 263.—VIEW OF THE MASTOID REGION.

mi, Meat. audit. ext. oss.; *sp*, Spina supra meatum; *z*, Proc. zygomaticus; *l*, Linea temporalis; *ac*, Area of the middle portion of the mastoid process, at which the chiselling should be done in acute abscess-formation; *an*, Area on the upper portion of the mastoid process, at which chiselling is done to lay open the mastoid antrum.

ingenious double hook, the prongs of which are separated by a screw attachment, is very serviceable in private practice when the operator is only

poorly supplied with assistants. All instruments must be boiled for three minutes in a 1 per cent. carbolic acid and soda solution, fifteen minutes before using. The scalpel should only be dipped in the carbolic solution immediately before the operation. That the most rigid antiseptic precautions must be carried out during the operation, by the operator as well as assistants, is self-evident.

Before the operation the external meatus is washed out with an antiseptic solution, then dried, and the external opening of the ear stopped with cotton-wool. The hair is then shaved from the region of the mastoid, and the skin cleaned with soap, sublimate solution (1 in 1,000), and finally with sublimate æther. The narcosis* should now be proceeded with by an experienced person, careful attention being given to the pulse and respiration. In order to guard against accident the physician in charge of the narcosis should have charge only of that, and have nothing to do with the operation. The narcosis, when it is complete, may be occasionally interrupted, and again continued when the patient shows signs of wakening.

Operation.—While the assistant bends the auricle forwards the operator makes a vertical incision, ½ cm. behind its insertion, slightly curved forward, and 4 to 5 cm. long, through the skin in the region of the point of the mastoid process and continued through the fascia and periosteum down to the bone. When this is done the periosteum, which is sometimes loosely and sometimes closely adherent, is shoved away from the line of incision backwards and forwards with a sharp-edged elevator until an area of about 1½ to 2 cm. of the middle portion of the mastoid surface is laid free. The hæmorrhage is stilled by drying with a sterilized tampon of sublimated gauze and by torsion of the bleeding vessels with an artery forceps. It is rarely necessary to ligature the larger bleeding vessels. Usually the hæmorrhage ceases itself upon using the two retractions with which the edges of the wound are held apart by an assistant during the operation.

If the middle portion of the mastoid plane (¾ to 1 cm. behind the osseous meatus and about 1 cm. above the lower point of the mastoid process) is laid free, a piece of the cortex 1 cm. wide and about 1½ cm. vertically is chiselled out with a large gouge (Fig 258) set at an angle. Frequently the abscess is reached after the first blow with the chisel, from which the pus rapidly flows, a fact which shows that it is under high pressure in the cavity. In other cases one or more small abscesses are found at a depth of ½ cm., and rarely at a greater depth. Where the abscess is in the lower portion of the mastoid process the operation opening must be lengthened below.

When the abscess cavity is opened the opening in the bone is enlarged partly with the chisel, partly with Luer's forceps in the

* Billroth's mixture: Chloroform 100, Alcohol and Æther Sulph., āā. 30.

direction in which the cavity extends, and the fungoid granulations and softened bone tissue scraped away with the sharp spoon already described (Fig. 261). With some experience one can easily differentiate the diseased tissue from the normal; the first gives a way easily for the sharp spoon, while the normal tissue offers a certain resistance. In long-existing extensive abscess-formation it is occasionally necessary to take away the greater portion of the mastoid process to the lowest point and the sinus lateralis, the latter of which is sometimes found lying free. The severe venous hæmorrhage during the scraping of the abscess cavity is quickly stopped by tamponing with iodoform gauze. Almost without exception, there was no communication between the abscess and mastoid antrum in the large number of cases operated on by me. The establishment of an opening between the two is not wished in any case of acute middle-ear inflammation, as the wound cavity, which is disinfected after scraping, would become infected by the pus from the antrum.

After thoroughly scraping out the abscess cavity it should be irrigated with a weak sublimate solution and the cavity lightly packed with iodoform gauze. In order to make the wound somewhat smaller several sutures are taken in the skin, the number of which depends upon the loss of substance in the bone. In superficial abscesses with slight loss of bone substance, the wound, after lightly dusting with iodoform, can be sutured immediately after the operation without consideration.

With deeper wound cavities the external wound in the skin should be narrowed by using two skin sutures at the upper and lower angle, and an iodoform bandage applied in order to observe its course, as pieces of diseased bone may remain, which will require repeated scraping out. The bandage should be removed every 5 to 6 days, and should only be renewed earlier in those cases where severe pain or fever occurs after the operation, or if the secretion soaks through at the end of 1 to 2 days. If the bandage is left too long the granulations will grow into the iodoform gauze, and severe bleeding may occur when it is removed. If after changing the bandages several times, the gauze is not saturated with pus and the edges of the wound are covered with healthy, red granulations, they may be brought together with a suture after cocainizing, as suggested by Gruber, by which means the healing is often shortened.

The favourable effect of opening a mastoid abscess is manifested in most cases shortly after the operation by a rapid fall of the fever temperature occasionally below the normal, through the disappearance of local pain, and the general well-feeling of the patient.

Opening of the abscess has a very favourable influence in most cases upon the suppuration in the tympanic cavity, although no communication exists between the two. Several days after the operation the discharge from the ear decreases and completely ceases in from 6 to 14 days, with cicatrization of the perforation in the membrana tympani.

The average duration of the wound treatment until complete cicatrization varies in the regular course from 2 to 5 weeks. Irregular course of the wound is observed in infectious middle-ear affections, occasionally with influenza, in cachectic individuals, and when the abscess cavity has not been sufficiently scraped out. Unfavourable symptoms during the treatment of the wound are: frequent increase of the temperature curve, suppuration in the wound cavity, abscess-formation in its vicinity, erysipelas, headache and vomiting, which signify a consecutive intra-cranial affection. A close examination of the wound cavity and the further removal of all remaining particles of carious or necrotic bone and fungoid growths is sufficient in many cases to produce a normal course of healing. Fatal results from meningitis, sinus-phlebitis and pyæmia are, on the whole, rare, and are usually seen in tuberculous and cachectic individuals.

(*c*) *The Secondary Chronic Diseases of the Mastoid Process.*

In the course of chronic middle-ear suppuration, pathological changes in the mastoid process occur almost without exception. As in the acute form, the anatomical variations in the mastoid process are of importance for the extension of the disease process, in so far that the pneumatic mastoid process is more frequently and intensely diseased than the diploëtic and compact. Almost always the mastoid antrum participates in the inflammatory processes of the tympanic cavity.

The pathological changes in the mastoid process occurring with chronic middle-ear suppuration are classified as follows: 1. Redness, swelling and polypoid hypertrophy of the lining of the antrum and cells. 2. Complete filling and destruction of the mastoid cells owing to excessive hypertrophy and growth of the lining membrane. 3. Change of the granulation tissue filling the cells into bone and partial or complete eburnation of the mastoid process (osteo-sclerosis). 4. Collection of purulent or muco-purulent fluid or of a crumbling mass similar to tuberculous material in the antrum and mastoid cells. 5. Cholesteatoma formation in the mastoid process. 6. Circumscribed or extensive caries and necrosis of the mastoid

process followed by the sequelæ which will be described later. 7. In diploëtic and compact mastoid processes the disease is frequently localized to the mastoid antrum alone.

The changes in the mastoid process here described may occur separately or combined. In the following we shall principally confine our attention to the cario-necrotic and cholesteatomous processes as being practically of the most importance.

Etiology.—Inflammatory appearances in the mastoid process occurring with chronic middle-ear suppuration may be produced by the factors mentioned in acute ostit. mast.; farther by trauma and general diseases. Frequently, however, the inflammatory osseous disease in the mastoid process is produced by local changes in the ear itself. As principal causes are: hindered discharge, stagnation, seclusion and decomposition of purulent and caseated secretion in the mastoid process. The causes of these we have already mentioned: narrowing of the external meatus, small perforation opening in the membrani tympani, suppuration in the attic with perforation of Shrapnell's membrane, adhesion of the membrana tympani to the inner wall of the tympanic cavity with continued suppuration, occlusion of the mastoid antrum with polypi, granulations and cholesteatoma.

That the occurrence of a bacterial infection, especially the entrance of streptococci or of a tuberculous affection, during chronic middle-ear suppuration, frequently produces severe forms of mastoid disease is without doubt. The invasion of the epidermis from the external meatus, through the perforated membrana tympani into the mastoid antrum we have already learned as a cause of cholesteatoma of the mastoid process.

Symptoms.—Chronic inflammatory processes and their results in the mastoid process may exist for years without producing any symptoms, as is proved by the numerous observations of patients and confirmed by dissection. This is specially true of those progressive hypertrophies of the lining of the mastoid cells going on, to filling up of the cells and eburnation, in which only rarely intermittent neuralgic pain occurs through the occlusion of the hypertrophied mucous membrane (Hartmann).

On the other hand an inflammation in the mastoid process frequently develops, following a cold, traumatism or retention of secretion, with symptoms the intensity of which frequently exceeds those of acute mastoid ostitis. The most prominent symptoms are: severe throbbing, boring pain in the mastoid region, radiating as far as the neck; severe tenderness, especially in the middle and upper portion of the mastoid process; moderate or severe fever, sleeplessness, head-

ache, tinnitus, and rarely dizziness and vomiting. If the disease is in the deeper layers of bone then the external integument of the mastoid process remains longer unchanged, especially with diploëtic and compact processes, when the suppurative process is in the mastoid antrum. If the inflammation is superficially situated or is very extensive, a diffuse, reddish, hard or indistinctly fluctuating swelling develops on the mastoid process, sometimes slowly and sometimes rapidly, extending over its borders posteriorly and towards the vertex, and occasionally is associated with an œdema of the face on the affected side extending to the eyelids.

The examination of the external meatus shows nothing different from the usual appearance in middle-ear suppuration, or the meatus may be narrowed through infiltration of the cutis or depression of the posterior superior wall so as to be impassable. When the lumen of the meatus is free, the perforated membrana tympani, often adherent to the promontory, appears swollen and granulated, the perforation filled with pulsating pus from the polypoid mass filling the tympanic cavity, or with a cholesteatoma. The discharge, sometimes profuse, sometimes scanty from retention, is sanious or thick, crumbling and ill-smelling.

The chronic septic suppuration from the perforated membrana Shrapnelli and from fistulous openings in the posterior superior quadrant of the membrana tympani, frequently associated with chronic suppuration in the mastoid antrum, have been already described.

Course and Result.—During the course of chronic middle-ear suppuration, intercurrent inflammation in the mastoid process, accompanied by symptoms of irritation, frequently occur and disappear without abscess-formation. They are, without doubt, often the foundation of osteo-sclerosis or caseous osteitis. In other cases the reactive inflammation in the mastoid process goes on to abscess-formation with the same symptoms and results as we have already learned by the acute middle-ear suppuration. Most frequently, however, the clinical appearance of inflammation and abscess-formation in the mastoid process develops where it has already been pathologically changed for a long time. It has been proved by experience that septic suppuration, growth of fungoid granulations, cholesteatoma and necrotic destruction of the lamellæ of bone separating the cell spaces, may exist for years in the mastoid process before the outbreak of severe inflammatory symptoms. In these last-named cases, if acute inflammation occurs through catching cold, trauma, retention of pus or bacterial infection, extensive destructive changes frequently result within the mastoid process, and, as has frequently been men-

tioned, dangerous complications may occur through extension to the neighbouring sinus.

The inflammations of the mastoid process with tubercular phthisis and resulting in caries and necrosis occasionally run their course without symptoms.

A case of tubercular middle-ear suppuration observed by me (woman aged 36), in whom the normal appearing mastoid region was not tender on pressure, showed upon dissection, besides the destruction of the membrana tympani, the whole mastoid process was transformed into a cavity containing pus and fragments of bone, and this was so softened that the cortex was broken in by moderate pressure. A phthisical girl, aged 18, with profuse middle-ear suppuration, and no symptoms of disease in the mastoid process, showed at the necropsy, after removal of the exterior soft portion, an almost complete destruction of the posterior wall of the meatus (Fig. 264) and in the upper portion of the mastoid process a cavity covered with smooth granulation tissue, which was in immediate contact with the meatus. Within a defect in the cortex of the mastoid process, 2 cm. in size, lay a movable cellular sequestra the size of a hazel-nut. Moos (*A. f. A. u. O.*, Bd. III.) found the central portion of the mastoid process sequestrated in a case of middle-ear suppuration without symptoms.

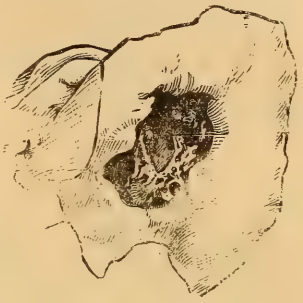

Fig. 264.

Inflammation in the mastoid process with the formation of abscess and caries more frequently develops with severe reactionary symptoms which are produced by the seclusion of the septic contents of the abscess or by the incarceration of a sequestra. The destruction produced by this may extend in different directions in the mastoid process and break through its borders. The formation of sequestra in the mastoid process has already been discussed in the previous section.

The most frequent place for perforation is the external cortex. It occurs with severe congestion and the formation of a tumour on the mastoid in its vicinity. The infiltration, at first hard, shows a distinct fluctuation after the perforation of the cortex. If in such cases the abscess is not previously opened the skin will be broken through in one or more places, after which the contents of the abscess will discharge, and the reactionary symptoms disappear. Often the opening in the skin corresponds with that of the bone, so that a sound introduced into it will penetrate directly through the opening in the bone into the mastoid process. In other cases the

opening in the skin is at a distance from that of the bone, which will only be found by laying free the surface of the mastoid.

More rarely the perforation of the mastoid abscess occurs on the posterior superior wall of the meatus (Fig. 265). The same often precedes a long-continued inflammation of the periosteum of the meatus with extensive bulging and sinking of the covering of the meatus. Its significance for the diagnosis of mastoid abscess has already been mentioned.

Fig. 265.

a, Cavity of abscess in mastoid process; *b*, Site of rupture on the posterior superior wall of the meatus; *c*, Lining membrane of the meatus swollen out to the anterior inferior wall; *d*, Inner portion of the external auditory meatus; *e*, Tympanic cavity.

From a therapeutic view its diagnosis is of importance, since, by incision of the bulging meatus at the proper time, the collected pus, caseous exudate and epidermis masses, small splinters of bone or larger sequestra may be emptied into the meatus. When it perforates spontaneously, extensive granulations shoot out from the edges of the perforation, which may simulate a polypus until the discharge of purulent or caseated secretion between the granulations is seen, or by sounding is found a granulated fistulous opening which will appear more plainly if the growths are removed.

After the breaking through of the cortex, or posterior wall of the meatus and after spontaneous emptying of the disease-products from the abscess cavity, it is often filled with ossifying connective tissue. Following the healing there often remains, especially in children, a depressed cicatrix on the mastoid process. In other cases, a suppurating, granulating cavity, with one or more fistulæ, may remain on the mastoid process for years, or during the remainder of life. That with epidermized fistulous openings the abscess cavity may become the seat of cholesteatoma through the invasion of the epidermis after the suppuration ceases, has already been described. Rarely large polypi develop in the cavity of the mastoid process and extend into the external meatus (Trautmann), or, as in one of my cases, a cauliflower-like new growth, the size of a nut, grew through an opening in the external covering of the mastoid process, and was removed with a wire snare. With large openings in the mastoid process it is often possible to see a portion of tympanic cavity and the entrance of the osseous Eustachian tube.

More rarely the mastoid abscess bores its way through the incisura mast. or on the median side of the mastoid process. Those pneumatic mastoid processes are specially disposed in which the

lower portion is formed of one large thin-walled cavity or of several large spaces which are limited below and towards the median line by an osseous lamella often as thin as paper (Bezold). The pus will more easily bore its way down and in if at the same time the external corticalis is thick and compact and offers a greater resistance to the abscess.

The perforation of the abscess on the lower and median side of the mastoid process frequently induces protracted complications as the pus extends in the subfascial layers of the neck and along the coverings of the larger vessels, producing an extensive painful infiltration of the cervical region below the mastoid process (Guye). The subfascial abscess produced by it usually bores its way out on the side of the neck, or a depression abscess follows which in some rare cases may produce a fatal result from pyothorax or by compression of the trachea (Jacobi).

The diagnosis of an abscess perforation on the median side of the mastoid process is most probable if, with the cessation of pain in the mastoid process, a hard tender tumour develops below it extending towards the cervical region, while the mastoid region itself shows no infiltration.

In many cases the abscess breaks through in different directions as on the cortex and in the external meatus. After the healing of such bone processes, I have seen in several cases a canal lined with epithelium in the mastoid process with one fistulous opening on the external cortex and the other on the posterior wall of the meatus. Perforation has also been observed externally and into the cranial cavity with the formation of subdural abscesses and protrusion of the brain (Kuhn).

The conditions following the perforation of the mastoid abscess through the tegmen of the mastoid antrum into the middle fossa of the skull and into the transverse sinus, resulting in meningitis, abscess of the brain, and sinus-thrombosis have already been described. We would also refer to a previous description for those abscesses and fistulous openings which occur with cario-necrotic processes in the mastoid process.

Diagnosis.—The diagnosis of inflammation of the mastoid process accompanied by reactionary symptoms, is made in most cases from the same group of symptoms as occur in mastoid ostitis during acute middle-ear suppuration. The diagnosis is much more difficult in those chronic diseases of the mastoid process with a latent course, for as we have seen, cario-necrotic suppuration, cholesteatoma formation, etc., may exist for years without symptoms. Even in those cases where externally there is nothing to show a mastoid

affection, from certain symptoms it is possible to conclude as to the presence of mastoid disease. As for example: persistent, septic, crumbling suppuration with perforation in the posterior superior quadrant of the membrana tympani, or a fistulous opening in Shrapnell's membrane. The diagnosis is scarcely questionable if the suppuration is accompanied by occasional boring pain and tenderness in the mastoid region. The probability that a protracted septic suppuration in the tympanic cavity is complicated with a suppuration of the mastoid antrum is more sure if, with moderate secretion in the tympanic cavity, a large amount of secretion can be aspirated from the posterior superior portion of the attic into the external meatus with the Siegle speculum. Frequently-recurring and long-continued boring pain in the mastoid process, without visible external changes and without the knowledge of pus-retention in the tympanic cavity offers no sure diagnostic point, as it occurs as well by deeply-seated secluded abscesses as from neuralgia in osteosclerotic mastoid processes. On the other hand, one can conclude with probability as to suppuration in the mastoid process when there are granulations and cholesteatomous formation in the tympanic cavity, or with narrowing of the external meatus symptoms of pus-retention (fever, chills, headache and vomiting) are present even when no pain occurs either spontaneously or upon pressure.

Prognosis.—The prognosis of chronic disease of the mastoid process is frequently indefinite, as the extent of the disease in the mastoid process can only rarely be determined from the objective and subjective symptoms. In general the prognosis is better in inflammations which develop with reactionary symptoms, if after 2 to 3 days redness and swelling occur on the mastoid process, symptoms which signify a superficial location of the inflammation. The prognosis will also be better if a cario-necrotic process in the tympanic cavity and external meatus can be excluded by the examination with the mirror. The prognosis is unfavourable, on the other hand, with accompanying caries of the walls of the tympanic cavity, with occlusion of the cavum tympani through granulations and cholesteatomous masses, with excessive narrowing of the meatus, and in cases which show at the first observation symptoms of intra-cranial complications, or sinus-thrombosis. In general, diseases of the mastoid process offer a better prognosis in healthy individuals than in cachectic and tuberculous persons.

Treatment.—The treatment of affections of the mastoid process varies according to the duration and intensity of the inflammatory symptoms, and according to its complication with deeply-seated changes in the tympanic cavity, and in the external meatus.

The antiphlogistic treatment of the mastoid disease, with chronic middle-ear suppuration, is of less value than in the inflammation occurring with acute otitis media. This is explainable if one considers that in the chronic form we seldom have to deal with changes which are removable. The antiphlogistic treatment may also be tried in chronic cases where the symptoms of inflammation have not existed long, provided dangerous symptoms or a retention of pus do not demand immediate operation.

Through the application of Leiter's apparatus, and painting the surface of the mastoid with tincture of iodine, or ung. ciner., combined with syringing out the tympanic cavity through the Eustachian catheter, it is possible in most cases to cause the inflammation to subside either temporarily or permanently. If the antiphlogistic treatment has no permanent result, the inflammation in the mastoid remitting after a shorter or longer time, there are evidently deep changes in the mastoid process which will require the laying free of the diseased mass.

In other cases of occasionally recurring inflammation in the mastoid process, it is possible to produce permanent healing by removing the granulations and cholesteatomous masses from the tympanic cavity, by removing the carious hammer and incus, and washing out the attic and tympanic cavity with either Hartmann's or the elastic cannula. In regard to this unsafe method, as Stacke calls it, I have only to remark, that I have had under observation a number of cases for years which have been permanently healed by repeated antiseptic syringing out of the attic, and who rejected the proposed opening of the mastoid through fear of the operation.

Wilde's incision, which was formerly used in reactive inflammation of the mastoid process, is only rarely used now. It consists of a perpendicular incision down to the periosteum, 4 to 5 cm. long, through the infiltrated covering of the mastoid process behind the auricle. The incision has for its object to relieve the tension of the infiltrated portion and thereby reduce the pain, farther to empty the pus from the sub-periosteal abscess, and following the breaking through of the cortex to find the opening, and penetrate into the interior of the mastoid process. The making of the incision behind the insertion of the auricle renders it possible to eventually use it in opening the mastoid process. I use the Wilde incision at present only in mastoid periostitis, and in those painful swellings on the mastoid occurring during simple acute middle-ear suppuration. In these cases the symptoms of mastoid inflammation are frequently seen to quickly subside. On the other hand, with marked symptoms of abscess-formation in the mastoid, especially

in influenza-otitis, where a collection of pus is almost always found in the mastoid upon operation, the Wilde incision should be discarded, and the mastoid process opened at once. Wilde's incision is of still less use in mastoid inflammation during chronic middle-ear suppuration, as the anatomical changes which develop here exclude a lasting benefit from this procedure.

Operative Opening of the Mastoid Process in Chronic Middle-ear Suppuration.

Operative opening of the mastoid process has for its object the removal of collections of pus, detritus, cholesteatoma or caseated exudate from its interior, and through laying free the mastoid pus to establish a communication with the tympanic cavity. By this means it is possible to wash out the whole middle ear, and by removing the stagnant and foul secretion to prevent the occurrence of the more dangerous brain and sinus diseases.*

The opening of the mastoid process in chronic middle-ear suppuration has had important modifications in the last few years in consideration of the variable extent of the disease in the temporal bone. Where the bone affection is localized in the mastoid process, it is usually sufficient to open it, scrape out the diseased portion and lay the antrum free, in order to effect permanent healing. Not unfrequently, however, the disease of the mastoid process is combined with caries of the osseous meatus, tympanic walls and ossicula and septic inflammation, with cholesteatomous formation in the attic, in which cases opening of the mastoid antrum must be followed by partial or total removal of the posterior superior wall of the meatus, and the laying free of the tympanic cavity. The former indications given by Schwartze and technical methods of operation have also been modified in many ways.

Indications.—Opening the mastoid process in chronic middle-ear suppuration is indicated :

1. With painful inflammatory infiltration of the covering of the mastoid process, especially if an accompanying narrowing of the meatus, or a clogging of the tympanic cavity with granulations, makes a stagnation of pus in the mastoid process probable. The operation is urgent when it is not possible to quickly remove the hindrance to the flow of pus, when the inflammation is accompanied

* Operative opening of the mastoid process was first done by Riolan about the middle of the seventeenth century, according to others by Petit (1750) and Morand (1651), later by Jasser (1776). For the knowledge of its important practical significance we have to thank v. Tröltsch and Schwartze.

by high fever and symptoms of meningeal irritation, and lastly when secondary inflammation in the mastoid process has repeatedly occurred.

2. With spontaneous pain in the mastoid process, which is increased by pressure, accompanied by bulging and sinking of the posterior superior wall of the meatus even when the mastoid process shows no external change. The operation is also urgent here, if after extensive incision of the bulging cutis and periosteum in the meatus, no emptying of the secretion, or only to an insufficient degree, occurs, and no decrease of the pain follows.

3. With persistent or occasionally remitting pain in the mastoid process, without swelling of the external integument, and without visible hindrance to the flow of discharge from the tympanic cavity, if there exists marked tenderness on the mastoid process. The operation is indicated as well, whether in such a case we have to deal with a deeply-seated bone abscess not communicating with the meatus, or with a painful hypertrophy of the mucous membrane in the mastoid cells.

4. With cholesteatoma in the tympanic cavity if after removal of the mass, and also extracting the hammer and incus, the suppuration continues, and by long-continued syringing of the attic greasy epidermal lumps are washed out of the posterior superior portion of the attic. The diagnosis of a cholesteatoma in the mastoid process is made more probable by the occasional occurrence of pain in the bone.

5. With fistulæ in the mastoid region and with gravitation abscesses below it.

6. With extensive caries and necrosis of the posterior osseous wall of the meatus. In this case the operation is combined with loosening of the auricle.

7. In all cases where during a middle-ear suppuration symptoms of meningeal irritation, or a beginning sinus-phlebitis occur, even when the mastoid process does not appear changed externally.

8. With protracted, septic suppuration from the attic which, in spite of removing the hammer and incus and several months' energetic treatment, is not changed. Laying free the antrum and eventually also the attic is then indicated if otherwise no symptoms of a mastoid disease are present.

9. With pain in the mastoid which develops in certain rare cases of connective-tissue hypertrophy (Hartmann), in osteo-sclerosis, or in osseous scars after the healing of a mastoid operation (Politzer).

The operative procedures in chronic mastoid disease are quite different from the opening of an abscess in acute mastoid ostitis.

While in the latter the operative procedure is limited to the vertical portion of the mastoid, in the chronic processes the mastoid antrum must always be opened and under certain conditions the tympanic cavity must also be laid free. We should keep in view the fact that in chronic cases the field of operation is in immediate connection with important structures, as the transverse sinus, the middle fossa of the skull, the facial canal and the horizontal semicircular canal, so that the operation should only be done by specialists who are skilful in surgery. To become sufficiently skilful the operation should be done at least forty times on the cadaver.

Before we proceed to the description of the operation, it must be stated that we possess as yet no means to tell before the operation whether we have to do with a pneumatic, diploëtic or compact mastoid process. We also have no means of determining an abnormal position of the transverse sinus which comes into consideration when opening the mastoid antrum.

Of great importance, in my estimation, is the fact that the abnormal position of the transverse sinus, outwards and forwards, occurs most frequently in diploëtic and compact mastoid processes and much more rarely with the pneumatic mastoid. With the latter the conditions for operation are, on the whole, more favourable. Great care should therefore be taken when operating upon a diploëtic or compact mastoid process in working towards the mastoid antrum.

The former expectant method of treatment used by many for chronic disease of the mastoid process is to be avoided. The experience of the last few years has given evidence that opening the mastoid process, when skilfully carried out, is without danger, and that the disease itself by long standing produces dangerous symptoms which may be relieved by the operation. Also the former contra-indication for operating upon the mastoid process —marked symptoms of cerebral or sinus affection—have no place now, since such favourable results have been obtained from the operating upon cranial abscesses and the sinus transversus. Even the operation in diabetic persons (Kirchner) which was feared up to within a short time, has been advocated lately by Kuhn, Schwabach and Körner.

The drill trephine for opening the mastoid process, which is even yet used in England and America, is to be avoided on account of its uncertain and dangerous penetration, and on account of the dirtying of the wound with the shavings of bone. The most rational and safest procedure has proved to be the chiselling, as we remove carefully the layers of bone and so are able to avoid the danger which arises from an anomalous construction of the mastoid process (Schwartze).

The instruments used in opening the mastoid process as well as the preparations for the operation, have been already mentioned.

Operation.—The operative procedure used in opening the mastoid process depends upon the condition in the mastoid itself, and upon the accompanying changes in the external meatus and tympanic cavity. Although in certain cases the method of operation can be previously determined, yet frequently the *modus operandi* will first be determined by the changes which the operation brings into view in the mastoid process, and on the posterior wall of the meatus.

With the chiselling away of the mastoid process there comes into consideration the opening of the vertical portion, and of the mastoid antrum. The combined opening of both is usually sufficient, where the disease of the vertical portion was known previously, or first becomes known during the operation. In diploëtic and compact mastoid processes, on the other hand, we must limit the operation principally to opening the antrum.

If there is no symptom of caries of the meatus and tympanic cavity present, and the operation is limited to opening the mastoid, and laying free the antrum, the first portion of the operation—cutting through the soft tissues and chiselling away the vertical portion of the mastoid process—is only slightly different from the opening of a mastoid abscess in acute middle-ear suppuration.

The vertical incision, slightly curved forwards, is made $\frac{1}{2}$ cm. behind the line of insertion of the auricle, and parallel with it. It should extend nearly to the tip of the mastoid process, and be 4 to 5 cm. in length. The hæmorrhage should be stopped in the manner described. The periosteum should then be incised and shoved forwards and backwards with an elevator far enough, so that the middle and upper portion of the mastoid is laid free after inserting the retractors. The more the soft tissues covering the mastoid are infiltrated, the longer the incision through the skin must be, in order to afford sufficient room for chiselling. The upper end of the incision, when possible, should be directed forwards, parallel with the upper line of insertion of the auricle, in order that the incision can be lengthened anteriorly if it should be necessary to loosen the auricle later in the operation.

If after exposing the bone the cortex in any place should be found inflamed, discoloured, rough or broken through, it is better to penetrate at this place, as the diseased spot will be most surely reached from here. Usually it is the middle portion of the cortex, behind the external opening of the osseous meatus, at which the inflammatory and cario-necrotic changes appear. The operation in these cases will be the same as for acute mastoid abscess.

If the cortex is thin, as it is in most pneumatic mastoid processes, or is rotten and brittle from inflammation, a few light blows with the hammer are sufficient to make an opening in the cortex 1 to 1½ cm. in size, and lay the diseased portion free. If the cavity in the mastoid process proves to be very extensive, the opening in the cortex must be enlarged with the chisel, or with the curved Luer's forceps.

After chiselling away the cortex an irregular abscess cavity is often reached which is full of pus, detritus, or crumbling masses, containing a large movable or adherent sequestrum, or several small pieces of bone. In other cases one comes immediately upon cholesteatomous masses, after the removal of which an ill-smelling, foul secretion appears below, mixed with small fragments of bone. Lastly, the mastoid process may be filled with discoloured, fungoid granulations, which often extend even into the antrum, and are sometimes connected with similar growths in the tympanic cavity.

Now follows the extraction of any sequestrum present with the dressing forceps, and the careful scraping out of the cavity with a sharp spoon. Scraping on the inner and upper wall of the cavity must be done with special care, on account of the proximity of the transverse sinus, and the dura mater. Long-continued suppuration frequently destroys the osseous walls of the sinus, and it may then be easily wounded. After the scraping, the wound cavity must be repeatedly irrigated with carbolic solution (2 to 3 per cent.), or sublimate solution (1 in 2,000 or 4,000). If there is a large communication between the abscess cavity and the antrum, the irrigating fluid will flow out of the external meatus. The last symptom only shows a communication of the abscess cavity with the antrum and tympanic cavity when there is no fistulous opening in the external meatus through which the fluid can flow.

If after the scraping no communication between the abscess cavity and the antrum can be demonstrated, it will be necessary under good illumination to penetrate from the anterior superior portion of the abscess cavity, forwards and upwards, parallel with the posterior superior wall of the meatus as far as the antrum. With cario-necrotic processes, when the osseous tissue between the abscess cavity and antrum is rotten and yielding, it can frequently be removed with a sharp spoon of small size, and the antrum opened; a chisel is rarely necessary.

After a large communication has been established between the abscess cavity, antrum and tympanic cavity, and after careful examination of the wound cavity with thorough scraping away of any rough or granulated portions, the middle ear should be irrigated

as long as any crumbling masses are present in the water. The irrigation should always be done from the wound cavity, and not from the meatus, as in that case the wound would become infected from the septic secretion washed from the tympanic cavity. The cavity is now dusted with iodoform, tamponed with iodoform gauze, and a bandage of salicylated cotton applied, it being securely fastened by a number of turns of the bandage around the head (for after treatment see later).

In a similar manner the operation is done when there is a fistulous opening in the mastoid region; these are usually associated with carious, granulating cavities in the mastoid process. The incision should be a curved one, its concavity being forwards and should pass through the fistulous opening in the external surface, and after shoving back the periosteum, the opening in the bone should be enlarged as the point of operation. Scraping out the diseased portion and opening the antrum is done as already described. With fistulæ on the mastoid process there is frequently a cavity of varying size between the external integument and the cortex covered with fungoid granulations, which must be scraped away with a sharp spoon, and the callous edges of the fistulous opening removed.

The extensive opening of the vertical portion of the mastoid process is indicated farther with those mastoid abscesses which break through on the lower or median wall of the proc. mastoid. (Bezold), and are characterized by the formation of a large tumour below it on the side of the neck. After opening the abscess cavity and scraping it out with a sharp spoon, the infiltration on the side of the neck frequently disappears entirely. Occasionally, however, it is necessary, when the pus has entered downward, to open the abscess below the mastoid process, and irrigate it antiseptically from the operation opening in the mastoid. The treatment of such abscesses frequently requires several months before complete healing.

The operative procedure is different in those cases in which after laying free the surface of the mastoid the bone appears normal, and after chiselling away several lamellæ of bone it is certain that we have to deal with a diploëtic or compact eburnated mastoid process which has not been affected by the suppuration. In this case the site for operation must be selected at that point from which the mastoid antrum can be most easily reached. This is the anterior superior quadrant of the mastoid process (Fig. 263, *an*).* This

* As, according to Bezold, the width of the insertion of the auricle at the level of the upper wall of the meatus is about 15 mm. and is largely on the planum mast., the entrance opening must lie on the bone in front of the line of insertion of the

place is, according to Hartmann and Bezold, below the linea temporalis, at the level of the upper wall of the meatus, and about 7 mm. behind the spina supra meatum (Bezold), a name which is used to signify an inconstant pointed projection, varying in development on the posterior superior periphery of the external opening of the osseous meatus (Fig. 263, *sp*). This spine is, however, only of value for locating the operation when it can be felt in the position described. Where this is wanting it is recommended to use the place where the planum mastoid. bends into the posterior wall of the meatus as the anterior border of the operation opening, and the upper edge of the osseous meatus as the superior limit of the opening. This will be most surely found by feeling with a stout sound at the anterior part of the field of operation for the place where the planum temporalis bends into the upper meatus wall, or as Beck suggested, to insert a blunt sound between the membranous and osseous walls of the meatus, which is left in this position to serve as a guide during the chiselling. The location of the antrum is frequently marked by a depression, more or less extensive, behind the upper portion of the external opening of the meatus. It lies immediately behind the spina supra meat., and when found may be used as the site for operation. If the operation opening is made above the edge of the upper wall of the osseous meatus there is danger of penetrating into the cranial cavity and exposing the dura. The danger of wounding the sinus is also increased if the site for operation is located too far behind the external meatus.

Where one has in view the opening of the mastoid antrum in the shortest manner, after exactly fixing the place for operation (Fig. 263, *an*), a piece of bone, 1 to 1½ mm. in size, is removed with the largest gouge, and by gradually chiselling away the following layers the opening to the antrum is deepened. The funnel-shaped canal from without inwards is inclined strongly forwards, instead of running parallel to the posterior superior wall of the osseous meatus. Upon penetrating more deeply, as long as compact osseous tissue is met with, the smaller chisels must be used. If cellular or spongy substance is met with it is better to carefully scrape away with the sharp spoon until the antrum is reached.

In laying free the antrum particular importance should be given to the direction of the funnel-shaped canal. If it penetrates too nearly perpendicularly the transverse sinus may be wounded. If

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auricle. Comp. Politzer, *The Anatomy and Histology of the Human Ear.* Stone : London, 1890.

the canal is directed upwards too much the tegmen antri. mast. or tymp. may be perforated, and the middle fossa of the skull opened. If the osseous canal should be inclined too much downwards the compact osseous mass lying below the antrum, which surrounds the facial nerve, will be met with.

It is quite as important to know the length of the operation canal, beyond which it is not safe to go for fear of injuring the facial nerve or the horizontal semicircular canal. The measures given by the different authors vary according to the methods employed in determining the distance from the site of operation on the cortex to the antrum. According to Schwartze, the distance from the posterior edge of the operation opening to the antrum measures about 12 to 18 mm.; according to Bezold, from the anterior edge of the osseous opening it measures only 12 mm. On my numerous horizontal sections of temporal bones the distance varies from 6 to 15 mm. between the middle of the operation opening to the external wall of the antrum. As at a depth of 20 to 22 mm. the horizontal semicircular canal or the facial nerve is reached (Hartmann), one should not go deeper than 18 mm. in a fruitless operation; if the operation is situated far forward, not more than 15 mm. The size of the external opening in the bone should be about 12 mm., according to Schwartze, and according to Bezold only 7 mm. According to my experience it is better to have the opening of large size, 15 mm. or over, as in penetrating deeply it gives a better view of the field of operation. Occasionally it is necessary to enlarge the operation opening downwards, if chiselling in the anterior superior quadrant shows that the osseous disease has also affected the vertical portion of the mastoid process, which appeared normal externally.

The operation is most easily done in cellular mastoid processes, as after chiselling away the cortex the cellular, frequently rotten, tissue can be easily removed, while the space between the posterior wall of the meatus and the transverse sinus is usually wider, and the antrum, which is usually larger, lies more superficial.

The operation is much more difficult if the mastoid process is sclerosed by chronic inflammation, or is diploëtic or compact. I must mention here an anatomical fact which is of importance in opening the antrum. One frequently finds in temporal bones, in which the vertical portion of the mastoid process is diploëtic or cellular, that the mass of bone higher up and on a level with the mastoid antrum between the meatus and sinus is much thicker and more compact. As the operation canal extends through this mass of bone, it is clear that frequently enough it will be necessary to

chisel through the compact bone to the antrum. If the antrum is not reached at the maximum depth, either the direction has been mistaken or it is destroyed, as has been shown by anatomical examination.

Of the disturbing accidents during the operation should be mentioned the exposing or wounding of the transverse sinus. Exposure is not to be avoided even by the most expert operator, if owing to the sinus bulging forward only a thin wall of bone exists between it and the meatus (Hartmann). The bare sinus is known by a bluish-gray membrane appearing during the chiselling on the inner or posterior wall of the operation canal, which can be pressed back with a sound. This occurrence was formerly very much feared, but is not now considered dangerous, as there have been a number of observations (Schwartze, Lucae, Jacobson, Politzer, and others) where the uncovered sinus wall, after bandaging antiseptically, was covered with granulations, and healing occurred. The injury of the sinus with the chisel or by a splinter of bone is more serious, yet this cannot now be considered absolutely dangerous, since Knapp, Roosa, Emerson, and others, have known healing to occur after such injury, and since a successful result has been obtained after opening the thrombosed transverse sinus.

Penetration into the middle fossa of the skull, which was formerly considered one of the dangers of chiselling the mastoid process, does not now come into consideration. Even with the so-called angular position of the middle cranial fossa, the uncovering or wounding of the dura mater is not to be considered if the chiselling is done by a skilful and experienced operator. Besides, the laying free of the dura, according to the reports, is as little dangerous as that of the transverse sinus: a case of accompanying wound of the middle meningeal artery, which resulted in healing, has been reported. The injuries of the dura are more serious owing to the danger of a traumatic meningitis; that it is not absolutely dangerous is shown by the incisions made in the meninges for opening abscesses of the brain.

Where the opening of the antrum is unsuccessful upon penetrating to the maximum depth (18 mm.), or where one comes upon an abnormally projecting transverse sinus, and cannot proceed further on account of the danger of wounding it, the operation cannot be stopped if there are vital indications for it. In such cases the auricle and posterior membranous wall of the meatus should be loosened in order to chisel away the posterior superior wall of the meatus and reach the antrum (see later). As an interesting fact, it may be mentioned here that frequently after what are

called by Schwartze 'unsuccessful' operations, an unexpected favourable result is observed, in so far that pain which has lasted for weeks, fulness in the head, dizziness and tinnitus, disappear in a few days after the operation, and the chronic middle-ear suppuration ceases, with or without closure of the perforation (Schwartze, Orne Greene, Politzer).

If in a normal course of the operation the antrum is laid free, the wound cavity should next be irrigated with a sublimate solution, 1 in 5,000, through a soft rubber drain introduced into the operation canal. The irrigation of the wound cavity should only be done under slight pressure. The wound cavity should then be carefully examined, under good illumination, and any particles of bone, cholesteatomatous masses, or granulations in the antrum removed with a sharp spoon, rough pieces of bone scraped out, and the wound irrigated with an antiseptic solution until it flows from the meatus clear. This is now followed by dusting the wound with finely-powdered iodoform, the operation canal and antrum are packed with iodoform gauze, and covered with an antiseptic bandage. When the after treatment has to be continued a long time sublimated or salicylated gauze is used in place of iodoform on account of the occasionally occurring symptoms of intoxication.

A favourable result after opening the mastoid process and washing out the middle ear is often manifested within a few hours after the operation, through the cessation of the severe pain, decrease in the bodily temperature, and disappearance of the dangerous symptoms which existed before the operation. The influence upon the middle-ear suppuration is often seen within a few days after the operation by the rapid decrease of the secretion, and the disappearance of the sepsis. In some cases, in which there is no deeply extending complication in the external meatus or tympanic cavity, the middle-ear suppuration heals in a remarkably short time. Where the septic suppuration continues after weeks of careful after treatment, one is justified in believing that beside the mastoid affection a carious disease of the walls of the tympanic cavity or ossicula exists. If, after several weeks' treatment, lumps of epidermis repeatedly appear in the irrigating fluid, it is certain that there is a cholesteatoma in the attic. This complication requires the supplementary opening of the suppurating tympanic cavity, which will be described later.

The treatment after opening the mastoid antrum is of great importance for the final result. Only the most careful antisepsis and stringent supervision of everything used in changing the bandage can prevent a bad result during the treatment of the wound.

With a normal course of healing it is sufficient to change the bandage every 5 to 6 days. When the bandage is changed for the first time, after removing the iodoform gauze, the wound canal should be irrigated with a sublimate solution (1 in 10,000), the wound cavity examined carefully for remaining granulations and roughness, and after these have been scraped away a rubber drainage tube wrapped with iodoform gauze introduced as far as the antrum. This tube should be changed every time the bandage is renewed, and has proved the most useful means of drainage. The introduction of lead nails has been discarded on account of their frequent bad results.

Return of the pain after the operation, increase of the bodily temperature, rapid soaking of the bandage, or the continuation of the septic suppuration, require a daily change of the bandage, and investigation of the hindrances to healing. So long as the secretion is ill-smelling and contains crumbling masses, I use sublimate solution (1 in 10,000) for irrigation; after the disappearance of the bad smell, and a better condition of the secretion, irrigation with a solution of boric acid (1 per cent.), of salicylic acid (1 in 500), or of cooking salt (1 per cent.), is sufficient. The irrigation must be continued until the suppuration ceases. The postulation of Küster and Bergmann, that the syringing out of the operation cavity should be avoided, has very properly been discarded.

So long as the suppuration in the tympanic cavity continues, the communication between this and the wound canal should be kept open by continual drainage. For the same reason it is necessary from time to time to scratch out the granulations from the wound canal and antrum, which close up the opening in a short time. Only when there is a certainty that the suppuration in the tympanic cavity has ceased can the drainage be removed and the canal be allowed to heal. That the wound treatment must be combined with local treatment of the external and middle ear is evident.

The healing process after the operation goes on more or less rapidly, depending to a large extent upon the local changes in the mastoid process, upon the occasional complications in the tympanic cavity and in the external meatus, and lastly upon the condition of the health of the individual. Sometimes within the first few days after the operation severe attacks of fever occur, but without any farther disturbance. Under favourable conditions, the suppuration rapidly ceases in the tympanic cavity, and the operation cavity fills so rapidly with granulation tissue, that the wound canal and external opening closes within 2 to 3 weeks. In other cases in which carious particles of bone that were difficult to reach remain, or fistulous

openings into the external meatus exist, which are in connection with fistulæ and abscess cavities in the region of the temporal bone, farther with accompanying caries of the tympanic cavity, the process of healing is often very tedious, and requires repeated operative measures: enlarging the operation opening, scraping out, slitting up and scraping the fistulous canals, chiselling away the posterior wall of the meatus and laying free the attic. Abscesses which break through the inner surface of the mastoid process or through the incisura mastoid. also heal very slowly, especially those where the pus burrows down the side of the neck. Occasionally there remains, in spite of the most careful after treatment, a fistulous opening on the mastoid process connected with an abscess cavity, which requires a repetition of the operation. The duration of the after treatment, until the cessation of the suppuration and cicatrization of the operation cavity, varies in chronic cases from 3 weeks to 1½ years and over.

That the operation has a beneficial influence upon the condition of the general organism, has been sufficiently proved by experience. Reduced, anæmic individuals recover exceedingly rapidly. This can be understood if one considers that a collection of pus in a bone affects the quality of the blood and the nourishment. The removal of caseated exudate from the mastoid process is of importance in so far as the caseous osteitis can be the source of a bad form of tuberculosis of the lungs.

The Chiselling away of the Posterior Superior Wall of the Meatus and laying free the Tympanic Cavity.

It has been already stated that the osseous disease is not always limited to the mastoid process, but that it is frequently complicated with caries of the osseous meatus and the walls of the tympanic cavity. The collected experience in aural surgery for the last few years show that Schwartze's method of opening the mastoid process proves insufficient in many cases. For this reason different methods of operation have lately been originated, which have for their object the complete removal of the diseased portions of bone from the external meatus and tympanic cavity, and thereby securing the healing of those tedious septic middle-ear suppurations. The operation is limited to the chiselling away of a portion of the posterior superior wall of the meatus, and in a majority of cases the external wall of the attic (margo tymp.) is removed and the tympanic cavity laid free.

The indications for chiselling away the posterior superior wall of

the meatus are the following: 1. Fistulous formation on the posterior wall of the meatus, which is usually combined with a cario-necrotic disease of the mastoid process, or with a suppuration in the antrum, more rarely with suppuration in the external attic (Gellé, Politzer). 2. Abnormal sinking of the posterior superior membranous wall of the meatus, if, after incision of the tumour, caries of the osseous wall is proved by sounding. 3. Spontaneous perforation of a mastoid abscess or a cholesteatoma on the posterior superior wall of the meatus, if after removing the mass healing does not follow, but the suppuration continues and granulations grow from the abscess cavity into the meatus. 4. With hyperostotic narrowing of the external meatus, if dangerous symptoms of pus retention occur. 5. With unsuccessful opening of the mastoid antrum according to Schwartze's method, owing to sclerosis of the mastoid process, or abnormal position of the transverse sinus, if with the continuance of the stormy symptoms a vital indication for opening the antrum exists. 6. With combined fistulous formation on the mastoid process and in the external meatus.

The indications for opening the upper tympanic cavity and antrum at the same time, are: 1. Caries of the walls of the tympanic cavity and the ossicula. 2. Excessive growth of granulations in the tympanic cavity, and with cholesteatomatous formation in the attic. 3. If after opening the antrum according to Schwartze's method, the middle-ear suppuration continues in spite of careful after treatment for a long time, or if dangerous symptoms arise during the after treatment.

Before we proceed to the description of the newly proposed methods of chiselling away the posterior or posterior superior wall of the meatus, and exposing the antrum and attic, we will consider the anatomical relation of the osseous meatus to the mastoid process and antrum, which are of use in locating the site for operation. I have already shown* the practical importance of studying their relations on sagittal, frontal, and horizontally sawed sections of the temporal bone, and would urge the importance of preparing a large number of such sections as a preparation for chiselling away the posterior wall of the meatus, and for exposing the antrum and attic. It is only in that way that an idea can be obtained of the variable size and position of the antrum in pneumatic, diploëtic and compact mastoid processes. It is known that the lateral mastoid cells are covered anteriorly by the external portion of the posterior superior wall of the meatus. However, in one of the sagittal sections near the external opening of the osseous meatus (Fig. 266), the pneumatic cell cavities appear which, to a variable number and extent, form a communication between the lateral cell cavities and the

* Politzer, *The Dissection of the Human Ear in the Normal and Diseased Condition.* Stone: London, 1892.

medially located mastoid antrum. In this portion limited collections of pus, communicating with the antrum, occasionally occur, which break through at the external portion of the posterior wall of the meatus in the region of the sutura mastoideo-squamosa.

A sagittal section through the middle of the osseous meatus (Fig. 267) frequently touches the lateral border of the mastoid antrum. This lies more laterally than the tympanic cavity. The mastoid antrum is usually larger in the pneumatic than in the diploëtic or compact mastoid process. The lateral portion of the antrum, usually more deeply seated, forms an obtuse angle outwards with the higher medial portion, which opens into the attic. For this reason it is rarely possible to introduce a sound into the tympanic cavity after opening the lateral portion of the antrum. The lateral part of the antrum lies more behind the middle portion of the posterior wall of the meatus.

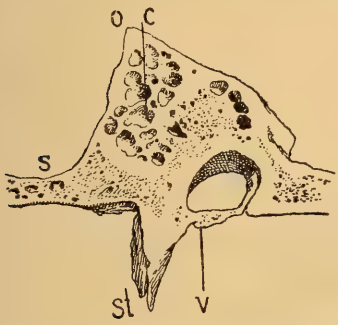

FIG. 266.—SAGITTAL SAW-CUT, 5 MM. MEDIALLY FROM THE EXTERNAL OPENING OF THE OSSEOUS MEATUS ON THE MACERATED TEMPORAL BONE OF AN ADULT. (RIGHT SIDE.)

v, Anterior lower wall of the osseous meatus belonging to the pars tymp. ; *c*, Pneumatic cell-spaces of the middle ear, situated along the posterior upper wall of the meatus ; *o*, Upper edge of the pyramid ; *s*, Sin. sigmoideus ; *st*, Proc. styloideus.

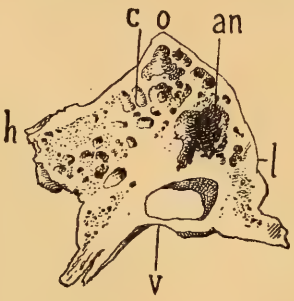

FIG. 267.—SAGITTAL SECTION, 3 MM. MEDIALLY FROM THE PREVIOUS ONE.

v, Anterior lower wall of the meatus ; *an*, Lateral portion of the antrum mast. ; *c*, Pneumatic cell-spaces ; *o*, Upper edge of the pyramid ; *h*, Its posterior edge.

The thickness of the posterior wall of the meatus at that part corresponding to the lateral portion of the antrum is very variable ; it is usually thicker in pneumatic than in diploëtic or compact mastoid processes. When the posterior wall of the meatus is very thick, it is possible to chisel this away without opening the lateral portion of the antrum. The median portion of the antrum, which goes into the attic without any sharp limitation, lies above the inner portion of the upper wall of the meatus. The external wall of this portion of the antrum, closing it off from the tympanic cavity, is partially formed by the posterior portion of the margo tympani of the attic. The wall of the meatus is much thinner here, and is always opened by chiselling away this portion of the anterior part of the antrum.

When chiselling away the posterior wall of the meatus, and laying free the attic, the topographical relations of the posterior wall of the meatus to the

ascending portion of the facial nerve is specially to be considered. This is studied best by a frontal section through the external meatus and tympanic cavity, which allows a view of the attic (Fig. 268). If the course of the facial nerve is followed from the inner wall of the tympanic cavity (*f*) to the stylo-mastoid foramen (*st*), it will be found that the Fallopian canal takes a course obliquely outward, so that a perpendicular to the stylo-mastoid foramen would come about the middle of the lower meatus wall. In this direction the facial nerve (*f*, *st*) goes through the compact mass of bone (*c*) below the antrum, which forms the lower part of the posterior wall of the meatus, and connects the inner portion of the lower meatus wall with the pyramid (Fig. 268, area *u*).

This mass of bone must be avoided in opening the antrum from the meatus on account of the danger of wounding the facial nerve. Such an injury is impossible if the chiselling is limited to the inner upper portion (Fig. 268, area *o*) which forms the floor and partially also the lateral wall of the

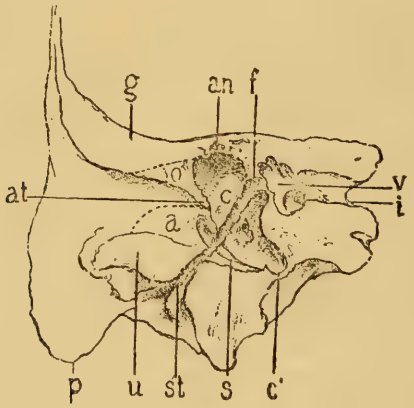

Fig. 268.

an, Antrum ; *f*, Beginning of facial canal ; *st*, Stylo-mastoid foramen ; *f* to *st*, Facial canal ; *u*, Inferior wall of meatus externus ; *o*, Floor of tympanic cavity ; *c*, Compact mass of bone ; *at*, The attic ; *p*, Point of mastoid ; *g*, Superior wall of meatus externus ; *g'*, Inner end of meatus externus ; *v*, Vestibulum ; *i*, Internal meatus ; *s*, Sulcus tympanicus.

antrum. Injury of the facial nerve is most easily avoided if it is possible to open the antrum from the mastoid surface by removing the external wall of the antrum (eventually the post. super. wall of the meatus) until the tympanic cavity is reached—a method which is especially recommended by Hartmann. Where sclerosed bone is found, or the opening of the antrum and attic can only be done from the inner portion of the meatus, on account of the abnormal prominence of the transverse sinus, one must always limit it to the upper portion of the posterior meatus wall, by which means the posterior prominent edge of the external wall of the attic (margo tymp.) offers a safe anatomical guide for laying free the antrum, and also to prevent penetrating into the facial canal, which lies underneath.

K. Wolf (Berl. kl. W., 1877) recommended the opening of mastoid antrum from the external meatus after previously loosening the auricle, but this proposition as well as that of Hartmann in the same direction only received notice in the last few years.

Prof. Küster* did the service to originate a method of operation based upon a ten years' experience, which must be considered a valuable acquisition to modern surgery. The method consists in the partial or complete removal of the posterior superior wall of the meatus, and also the external wall of the attic when changes in the tympanic cavity require opening of the latter. The broad and roomy opening of the suppurating osseous cavity allows the removal of all the diseased parts and an unhindered flow of the discharges from the middle ear. The method of operation proposed by Prof. v. Bergmann in the same year depends upon the same principle, but differs from Küster's method in many points.

Küster's method is as follows: In order to loosen the auricle from its insertion, $\frac{1}{2}$ cm. behind the line of its attachment a nearly semicircular incision is made, which extends from near the tip of mastoid process to anterior point of insertion of the helix. The soft tissues are then divided down to the periosteum, and this is shoved back with a sharp-cornered elevator, first backwards and then forwards, until the posterior superior edge of meatus is reached.

The membranous meatus is then separated with a small blunt elevator from its posterior superior insertion, until it can be drawn forwards and downwards, with the loosened auricle in the form of a cylinder. The exposed mastoid surface and the posterior superior wall of the osseous meatus should be carefully examined for carious places or fistulous openings after the hæmorrhage has been stopped.†

The *modus operandi* following varies according to the already visible changes on the exposed bone. As a rule, portions of bone, which are discoloured and infiltrated with pus, are next removed with a chisel; fistulæ in the bone are enlarged, and all softened osseous tissue, granulations and cholesteatomata are scraped out with a sharp spoon. If the caries or fistulous formation is limited to the external portion of the meatus—a localization which occasionally occurs with circumscript cario-necrotic collections in the mastoid process‡—it is sufficient to enlarge the fistulous opening and scrape out the cavity, which is usually not spacious, in order to cause the

* *Deutsche med. Wochenschr.*, 1889.

† *The Surgical Treatment of Brain Diseases*, 1889.

‡ I cannot concur with the statement of Küster, that in these cases we have to deal with a primary affection of the mastoid process, as such isolated collections may also occur in the mastoid process, secondary to suppuration in the cavum tympani and antrum.

chronic suppurative process in the mastoid to heal through granulation formation. After the curetting, the upper and lower angles of the wound are brought together by sutures, and only that portion of the external incision which corresponds to the wound cavity left open for the introduction of iodoform gauze until cicatrization takes place.

If the caries or fistulous formation affects the mastoid surface or the upper area of the posterior wall of the meatus, after chiselling and scraping out all diseased tissue, the posterior external portion of the antrum is laid free in order to penetrate into the tympanic cavity through the posterior superior wall of the meatus which forms the outer and lower cover of the antrum. If the bone does not appear

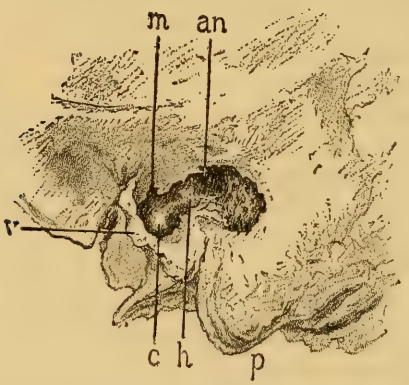

FIG. 269.—OPENING THE ANTRUM AND CHISELLING AWAY THE POSTERIOR SUPERIOR WALL OF THE MEATUS.

p, Processus mast. ; *v*, Anterior wall of the meatus ; *an*, Antrum opened by chiselling ; *h*, Posterior superior wall of the meatus chiselled away ; *c*, Cavum tymp. with the promontory ; *m*, External wall of the attic with the incisura Rivini.

changed externally the antrum is opened according to the typical method, and then the posterior superior wall of the meatus is removed as far as the tympanic cavity (Fig. 269). Straight and bent sounds can be used with advantage for exploring the direction in which it is necessary to penetrate with the chisel or forceps. When we can feel on one side the floor of the antrum, and on the other are able to introduce the sound into the tympanic cavity from the anterior part of the antrum, and when the point of the sound can be introduced into the region of the incisura Rivini, we are in a position to remove the portion of the meatus wall corresponding to the antrum, with a certainty of not touching with the chisel the compact portion of the posterior wall containing the facial nerve (Fig. 271, *f*) and lying below the sound. To explain Küster's

method, which is modified in many ways, the three accompanying cuts have been added to the text.

The removal of the meatus wall is either accomplished with a small gouge or with the straight Luer's forceps modified for this purpose by Zaufal. The latter are especially suitable, when after enlarging a fistulous opening into the antrum, one branch can be introduced into it, the other being in the external meatus.

When the posterior superior wall of the meatus has been removed, with the exception of that part where the membrana tympani is inserted (Fig. 269, *h*) the condition of the external wall of the attic (*m*) which is so often carious should be examined. As in such operations there is usually extensive destruction of the membrana

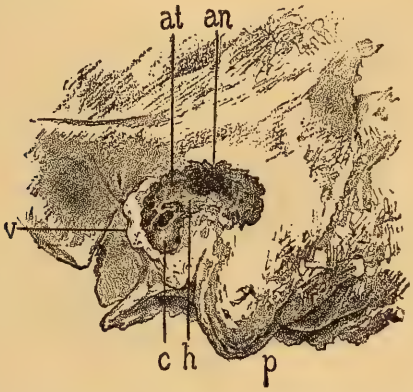

FIG. 270.—OPENING THE ANTRUM, AND CHISELLING AWAY THE POSTERIOR SUPERIOR WALL OF THE MEATUS, AND LAYING FREE THE UPPER TYMPANIC CAVITY BY REMOVING ITS OUTER WALL.

p, Proc. mast.; *v*, Anterior wall of the meatus; *an*, Antrum, opened; *h*, Posterior superior wall of the meatus chiselled away; *at*, Upper tympanic cavity (attic) after taking away its external wall; *c*, Cavum tymp. with the fenestra ovalis.

tymp., and granulations or cholesteatomatous masses in the tympanic cavity, in removing the inner portion of the upper wall of the meatus we do not have to consider the membrana tympani. If the middle and lower tympanic cavity is filled with polypoid growths or cholesteatomata, these should be removed with a small curette before the attic is opened, in order to obtain a better view of the tympanic cavity and avoid the dislocation of the stapes.

Chiselling away the posterior superior wall of the meatus is done after opening the tympanic cavity by successively removing the lamellæ of bone forming the outer wall of the attic (Fig. 269, *m*). This is carried out, as described in Stacke's method of extracting the ossicula, by chiselling away the external wall of the attic (Fig. 270, *at*) with a small gouge, until between the upper wall

of the meatus and the upper tympanic cavity no process of bone remains (Fig. 268, area *o*). The successive chiselling away of these layers of bone requires great care, owing to the immediate vicinity of the middle fossa of the skull; but with sufficient experience it can be carried out without thinking if the anatomical relations are clearly seen after removing the posterior superior wall of the meatus. Where the latter is not the case the properly-constructed bone forceps should be used to remove the outer wall of the attic.

Zaufal operates with a straight Luer's forceps, one branch of which he shoves directly into the attic. By this means he was able to remove the whole osseous wall of the attic with one stroke, and occasionally the hammer and incus were removed as well. This

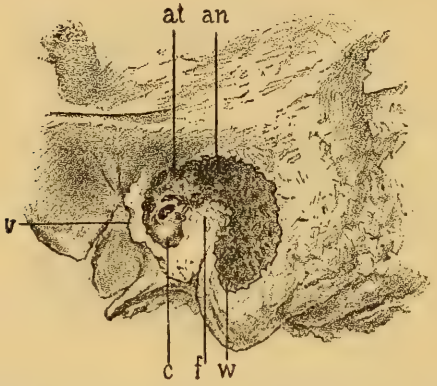

FIG. 271.—CHISELLING AWAY THE POSTERIOR SUPERIOR WALL OF THE MEATUS, AND LAYING FREE THE ATTIC AFTER MAKING A BROAD OPENING IN THE MASTOID PROCESS.

w, Mastoid process chiselled open; *an*, Mastoid antrum; *at*, Exposed attic; *c*, Cavum tympani; *f*, Compact portion of the posterior wall of the meatus containing the facial canal; *v*, Anterior meatus wall.

method appears to me, after experiments made with Luer's forceps, to be very difficult, owing to the too great dimensions of the branches, and to the difficulty of opening them sufficiently in the narrow operation cavity. Besides, as I demonstrated on the cadaver, by introducing one branch into the attic, the stapes can be dislocated, and the loosened hammer and incus shoved into one of the bulging spaces at the anterior inferior part of the tympanic cavity, from which they can only be removed with difficulty. In order to open the attic with more safety, it will be necessary in the future to construct delicate instruments of sufficient strength.

When the external wall of the meatus is removed, the hammer and incus, or the remainder of them, should be removed with the pincette, and in case the ossicula are encased in granulations or a

cholesteatoma, all the diseased mass should be removed with sharp spoons of different sizes.

With accompanying cario-necrotic disease of the mastoid process all the diseased tissue should be removed, by which means a broad communication is made between the tympanic cavity, external meatus, and mastoid process (Fig. 271). The more thoroughly the scraping is done the more surely can one reckon on the duration of the result. The curetting in the tympanic cavity requires great caution, as the region of the fenestra ovalis and facial canal must be avoided. That the dislocation of the stapes is said to produce no bad results if the necessary antisepsis is used, should not lead us to ignore the possibility of severe complications occurring from opening the labyrinth.

After the operation is ended the wound is again irrigated* with a weak sublimated solution, and tamponed with iodoform gauze. The auricle is replaced, and in order to approximate the loosened membranous meatus to the remaining osseous wall a sufficiently large drainage tube is introduced into the meatus. Whether the soft tissues are immediately sutured, or the wound is kept open for some time by the introduction of a drain depends upon the size of the defect in the bone. If, besides opening the antrum and attic, a large part of the mastoid process is excavated, it is better to leave open the portion of the external wound corresponding to the cavity in the bone in order, on the one side, to remove remaining pieces of carious bone, on the other to more easily introduce iodoform gauze into the cavity than can be done from the meatus. Where only the posterior superior wall of the meatus is removed, and the tympanic cavity opened, the wound in the skin may be sutured at once, as the iodoform tampon can be introduced from the meatus without difficulty. As the suppuration is slight after the operation, Küster recommends an infrequent changing the bandage, and as little syringing as possible.

The method recommended by Küster in sclerosis of the mastoid process for opening the antrum from the meatus, laterally from the membrana tympani, without at the same time laying the tympanic cavity free, is seldom practicable. On the other hand, a pressing indication for opening the antrum from the meatus in combination with laying free the attic (Stacke's method) is present in those cases in which dangerous symptoms occur, and the typical chiselling away of the mastoid process is impossible on account of its sclerosed condition, or on account of abnormal prominence of the transverse sinus.

* Küster and Stacke tampon the wound cavity without previous irrigation.

Of the 43 cases operated upon by Küster during a period of ten years, 19 were healed; in 4 the suppuration continued, 7 died of other diseases, the remainder were lost from observation. The time required for healing until the suppuration ceased averaged from four to eight weeks; it is thereby much shorter than the length of treatment required by Schwartze's method.

Bergmann's method (1879) of opening the tympanic cavity is as follows: Through a semicircular incision, 2 cm. from the upper insertion of the auricle, and parallel to the helix, the soft tissues are divided down to the bone, and this is shoved upwards and backwards until the upper and posterior edge of the osseous meatus is exposed. After loosening the membranous meatus a small chisel is placed below the linea temporalis, and the lower lamella of the upper meatus wall (Fig. 268), including the external wall of the attic, is removed. If the tympanic cavity is opened from above, the posterior wall of the meatus may be finally chiselled away, and the mastoid process opened from this.

Through the funnel formed in this manner, according to the statement of v. Bergmann, the carious ossicula, granulations and inspissated secretions can be removed with the sharp spoon. The after treatment consists in tamponing with iodoform gauze, and in the introduction of successively smaller grains, until the cavity is filled with granulations.

Hessler (*A. f. O.*, xxxi.) speaks against the Küster method. He recommends Bergmann's method of operation, after the typical chiselling of the mastoid process, in all cases in which the caries extends forward between the lamellæ of the squama.

Of 47 patients in whom Hessler chiselled open the mastoid process and middle ear, during a period of one and a half years, 36 were healed, 6 remained unhealed, and 5 died.

Stacke's method differs in many ways from those already described. Where the diagnosis of caries of the hammer and external wall of the meatus is positive, but a primary indication for opening the mastoid process does not exist, he recommends the method proposed by him for the extraction of the carious ossicula: loosening the auricle and membranous meatus, opening the attic, and lastly laying free the antrum. In cases, however, in which changes in the mastoid process indicate opening it, the antrum is opened in the typical manner, and after the removal of the posterior superior portion of the osseous meatus (not the whole posterior meatus wall, Stacke), the attic is laid free and the ossicula removed. This method offers the advantage that besides the membranous wall of the meatus, a portion of the periosteum of the

osseous wall is retained, which can be used for transplanting into the antrum and the defect in the bone. The transplantation is done as follows: the membrano-periosteal covering of the meatus corresponding to the defect in the bone is divided by two long parallel cuts, leaving a longish four-cornered flap, which after replacement of the auricle is made to lie on the wall of the antrum and defect in the bone by tamponing the meatus, and grows to it. By this means an epidermal covering is secured for the free communicating cavity, as well as the possibility of a constant supervision of the field of operation after the cessation of the suppuration. This method of operation is recommended by Schwartze for cholesteatoma of the mastoid process. Siebenmann recommends securing a permanent fistulous opening behind the auricle.

As to the changes which develop after chiselling away the meatus and opening the attic, there have been few reports. In Küster's 12 cases (43 operations) where examination was possible after a long period of time, 4 membrana tympani were cicatrized, 5 had perforations with a dry middle ear, and 3 had perforations with continued suppuration. Whether, and if so to what extent, the opened cavities are filled with granulation tissue, was not stated in Küster's paper. Strictures of the meatus have been reported. While Schwartze had a case of stricture after partial chiselling away of the osseous meatus, and in one of my cases operated upon in the clinic a stricture ensued, Zaufal and Stacke have never seen a stricture after the operation.

A final judgment of the new methods of operation described here is not yet possible, as the number of reliable observations is yet too small. So much can however be said, that these methods are a valuable addition to our surgical treatment of the ear, as it renders possible the alleviation of some cases of incurable middle-ear suppuration, and avoids their deleterious effects. Although by this procedure the suppuration is not always stopped, as is shown by the observations of Küster, Zaufal, Hessler and others, we should not discard it if we consider that the osseous disease in the temporal bone is not always limited to portions accessible to operation, but extend to places on the pyramid and squama which we are not able to reach by the most careful curetting. In what manner the methods of operation described must be modified according to the varying individual anatomical conditions of the temporal bone, and the special pathological changes, must be determined by the experience of the next few years. It will be a task for the clinicaires to form statistics for comparing the results of the different methods of operating on the mastoid process, in which the results for acute and

chronic middle-ear suppuration are separately given. The division is specially needful as the mastoid abscess in acute middle-ear suppuration heals, with few exceptions, after simply chiselling of the mastoid without opening the antrum. The previous method of including the results of acute and chronic cases together, makes it impossible to form a judgment of the value of opening the mastoid process in chronic middle-ear suppuration. For this reason I have not included the results of operations published.

New-formations in the Sound-conducting Apparatus.

1. *Connective-tissue New-formations.*

a. On the Auricle.

Of connective-tissue growths occurring on the auricle, the fibroma, the keloid cicatrix, and the myxofibroma are most frequently observed.* These tumours are developed principally on the lobe, usually in consequence of its having been pierced, and occur with special frequency in negro women (Turnbull). Their growth is slow and painless. They often attain enormous size, which, as in cases of Agnew and Turnbull, sometimes surpasses in circumference that of the auricle.

In almost all the known cases the fibroma attacked both sides, but was of unequal size in the two ears. They appear as globular, semi-globular, or lobulated, partly movable tumours of more or less solid consistency. They consist in the most part of fibrous connective tissue, which in a few cases is also mixed with mucous tissue. Fibroma of the auricle is benignant, as after total extirpation it does not recur. In a case described by Agnew a myxofibroma of the auricle, which originated in a traumatic cicatrix, always recurred after having been repeatedly removed.

Treatment consists in so extirpating the tumour that the cicatrix may not disfigure the auricle.

Angiomata are more rarely observed on the auricle. They appear as bluish-red, more or less pulsating tumours, from the size of a lentil to that of a walnut, situated at the entrance to the ear on the lobe (Kipp), or on the posterior or the anterior surface of the auricle. Sometimes several angiomata coexist on the auricle and its neighbourhood, as in a case of Turnbull's (*Lond. Med. Congr.*, 1881), in which one tumour was seated near the orifice of the ear, and another behind and above the ear, connected with it by a vascular cord. To this class belongs a case described by Mussey (*Am. Journ. of the Med. Sciences*, 1853, cited by Virchow), in which one angioma arose in the concha, a second on the tragus, and a third on the lobe, and involved the lateral cervical region between the angle of the lower jaw and the mastoid process.

Angiomata either date from birth or arise, as in Kipp's case, after freezing

* Knapp, *A. f. A. u. O.*, v.; Agnew, Turnbull, *London Med. Congr.*, 1881; Finley, *Philadelphia Med. Times*, ix.; Bürkner, *A. f. O.*, xvii.

of the auricle. Their growth is sometimes slow, sometimes very rapid. The dilated condition of the vessels extends sometimes to the meatus, the region of the ear, and the scalp. With a gradual growth angiomata cause scarcely any disturbance; with a rapid growth, on the other hand, throbbing pains are often experienced in the affected parts. By thinning of the skin on some parts of the tumour dangerous hæmorrhages may arise by rupture of the dilated vessels. In a case described by Jüngken, a fatal termination resulted from hæmorrhage.

The treatment of angiomata depends on their size and extent. In small, flat angiomata it is recommended to insert several aseptic silk threads, dipped in chloride of iron, through the tumour, in order to coagulate its contents and cause it to shrivel up. This method is in every way preferable to brushing with nitric acid and vaccination of the tumour. Growths with thin pedicles are best removed after the vessels have been partially atrophied by acupressure (Martin, *Gaz. des Hôp.*, 102). Chimani, in the case of a boy fifteen years of age, cured a considerable tumour after four weeks' treatment by repeated injections of liq. ferr. mur., and partial excision of the atrophied parts. Yet I must object to this method because, from the experience of eminent surgeons, it may lead to suppuration and ichorous ulceration of the tumour with subsequent sepsis and formation of thrombi. By the rational use of the thermopuncture by means of Pacquelin's thermocautère, that termination will not only be avoided, but cure will be much more quickly and surely effected than by the other treatment. In small tumours the operation can be completed at one sitting by the repeated insertion of the thermocautère. In large vascular tumours, on the other hand, it is better to extend the operation and perform it at intervals of five or six days, because, if extensive scabs are formed, reactive inflammation with great secondary hæmorrhage may readily occur. If there are near the auricle large arteries leading to the angioma, they must be subcutaneously ligatured before the operation. Jüngken cured one case by electro-puncture. Ligature of the carotid is necessary only when relapses occur, in spite of the repeated application of the thermocautère. Dupuytren, Mussey, and Weinlechner have had cures from this operation.

FIG. 272.

a, An angioma the size of a hazel-nut, firmly connected with the perichondrium.

b. In the External Meatus and in the Middle Ear.
Aural Polypi.

The pedunculated connective-tissue growths in the ear termed polypi, which are usually developed in the course of chronic suppura-

tion of the middle ear, less frequently in acute middle-ear suppuration or in primary inflammation of the external meatus, originate most frequently in the mucous membrane of the middle ear, more rarely in the external meatus and on the membrana tympani. The latter is, however, more frequently the site of polypi than was at one time supposed. The formation of polypi without previous suppuration is seldom observed.

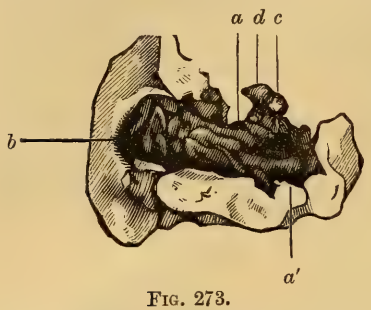

Fig. 273.

b, Polypus; *c*, *d*, Remainder of malleus and incus; *a*, Root of the polypus adherent to malleus and incus; *a'*, Second root of the same polypus springing from the inner and lower wall of the tympanic cavity.

The most frequent starting-points of polypi of the middle ear are the inner and lower walls of the tympanic cavity, the covering of the ossicula, more rarely the cells of the mastoid process and the mucous membrane of the Eustachian tube. In the external meatus their roots spring oftenest from the posterior superior wall of the osseous section near the membrana tympani, or partly on the latter itself, rarely in the cartilaginous portion. The root of the polypus can

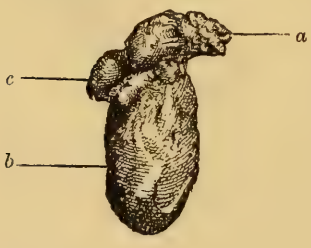

Fig. 274.—Fibrous Polypus of the External Meatus.

a, Root; *b*, Body of the polypus; *c*, Several hard excrescences growing near the root of the polypus. Radical extraction with Wilde's snare.

Fig. 275.—Fibrous Polypus of the External Meatus.

a, Root; *b*, Body of the polypus; *c*, Round excrescences of the size of hemp-seed growing on the posterior section of the polypus. Radical extraction by Wilde's snare.

Fig. 276.—Lobulated branched Polypus of the Tympanic Cavity.

a, Root.

either arise from the superficial or deeper layers of the cutis, or from the periosteum and the connective-tissue covering of the bones. On the membrana tympani the root of the polypus arises usually from the superior posterior section and from Shrapnell's membrane,

occasionally from the edges of a perforation or paracentesis opening. Very often simultaneous polypous growths are found in the middle ear, on the membrana tympani, and in the meatus.

The occurrence of polypi in the tympanic cavity without perforation of the membrana tympani is shown by the observations of Zaufal and Gottstein (*A. f. O.*, vol. iv.). They bulge the membrane outward, and may even produce perforation.

Aural polypi occur in one ear either singly or multiple. In cases of multiple polypi long contact may cause the union of two originally separate.

The size of aural polypi varies greatly. Most commonly they are

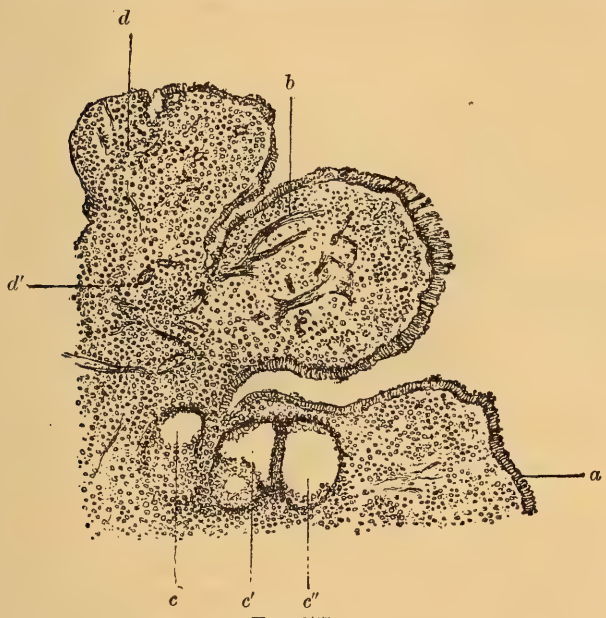

FIG. 277.

about as big as a pea or a large date-kernel, but they may attain a size greater than the longitudinal diameter of the meatus (Fig. 274), so that the tumour projects beyond the external orifice of the ear. On the other hand, it has been already mentioned that microscopically small polypi may occur in the middle ear and on the membrana tympani.

The form of polypi is generally long and club-shaped, more rarely globular or knob-like (Fig. 276). Their surface is smooth or lobulated, glandular and raspberry-like. Frequently in the neighbourhood of the root of large and smooth polypi a number of papillary excres-

cences are found (Fig. 275). The growth has either a broad base or a thin, pedunculated root.

Structure of Aural Polypi.—When one examines histologically a number of aural polypi one finds on the whole two leading forms, round-celled polypi, and fibromata. Pure myxoma, or principally epithelial tumours are rare.

The round-celled polypus (mucous polypus, cellular polypus) consists of a hyaline, homogeneous, myxomatous stroma traversed by a more or less well-developed fibrous framework, in which are enclosed scattered or thickly set round cells, and sometimes also a few spindle cells (Fig. 277, *d*, *d'*). By transformation of the round cells into spindle-shaped cicatrix cells the soft polypus receives a hard fibrous character. This transformation proceeds usually irregularly from the root to the body of the polypus. The surface of these polypi is seldom smooth, but is commonly glandular, papillary, with deep

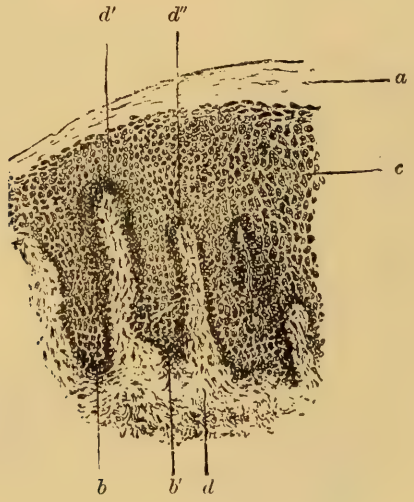

FIG. 278.

glandular indentations (Fig. 277). It is covered with an epithelium, which shows all the transition stages from simple ciliated epithelium to the complicated epithelium of the mucous membrane of the mouth (Fig. 277, *a*). In the interior of the polypus there are often enclosed cavities lined with epithelium (*c*, *c'*, *c''*) and cyst-like space (Steudener's retention-cysts) which probably originate in the adhesion of secondary or tertiary growth, whereby the original indentations come to occupy the interior of the polypus. Once I found such a cyst, of the size of a hemp-seed, filled with epithelium cells and cholesterine crystals. Localized and extensive degeneration of the tissue is not rare.

The true fibroma is distinguished from these polypi by the fine long-fibred, fibrillar construction of the stroma (Fig. 278), in which spindle-cells are also often interspersed. It is not so rich in vessels as the mucous polypus. Its surface is usually smooth and covered with pavement epithelium in several

layers, the uppermost of which (*a*) is cornified. The epithelium penetrates the tissue of the polypus in the form of long cones (*b*, *b'*).

Many polypi of the tympanic cavity contain central capillary loops (Billroth), and others are traversed by numerous bloodvessels, and receive thereby the character of cavernous polypi or angiomata. By the strong development of the interstitial tissue the bloodvessels are so contracted in the progress of the case that they partly atrophy, giving to the polypus, in longitudinal section, a striated appearance. Combined forms of angio-fibroma and angio-myxofibroma were described by Klingel. A few nerve elements have been found only in the bases of the polypi.

In some few cases, as shown by the observations of Bezold, Cassells and Hedinger, branching osseous deposits are found in the tissue of the polypus. As the ossification generally appears near the place of attachment of the polypus, it is probable that the osseous trabeculæ extend into the tissue of the polypus from the osseous floor of the meatus. Isolated ossification (Cassells) and calcification of aural polypi are rare.

A case of ear polypus seen by Morpurgo and myself is worthy of mention. It occurred in a man who died of general osteomalacia, in whom the first examination showed a round-celled polypus, while several years after the first removal it proved to be an osteo-sarcoma with an extensive network of bone. Upon its removal, I found the base was on the upper portion of the inner wall of the tympanic cavity.

The growth of the fibroma proceeds, as a rule, very slowly, that of the mucous polypus much more quickly. I observed one case in which, two days after the removal of a polypus from the tympanic cavity, a second transparent mucous polypus, 3 cm. long and 5 mm. thick, sprang up. The development of polypi without suppuration in the ear is extremely rare; I have only once observed the development of a hard bluish-red tumour of the size of a pea, on the superior wall of the meatus near the membrana tympani, take place several years after exhaustion of suppuration of the middle ear.

Symptoms and Results.—Aural polypi may persist for a whole lifetime without injurious effect. The most frequent symptoms are: a feeling of pressure, heaviness, fulness and pain in the ear, and often repeated hæmorrhages from the meatus. Sometimes, however, by offering a mechanical obstacle to the escape of the secretion, they occasion pain on one side of the head, a feeling of pressure and heaviness in the affected side of the head, giddiness and tinnitus, vomiting, incontrollable movements and epileptiform attacks. In a case of Schwartze's (*A. f. O.*, vol. i.), unilateral paresis and anæsthesia of the extremities of the affected side were cured by the extirpation of several aural polypi. Very often also by stagnation of the secretion, condensed cheesy masses are formed, which may by decomposition lead to caries of the bone and to fatal complications.

In regard to the termination of polypi, it has still to be mentioned that cure by spontaneous shrivelling seldom occurs, while, on the

other hand, spontaneous discharge of polypi frequently happens when, through turning of the new growth on its long axis, the blood-vessels are constricted. Occasionally broad-based polypi are cast off through gangrene without a discoverable cause. The production of atresia of the meatus through adhesion of the polypus with its walls has already been described.

The diagnosis of aural polypi is not difficult with some practice and with the use of the probe, by which the mobility of the tumour is ascertained. It is possible in but few cases to confound them with the bulging membrana tympani deprived of its epidermis or exostoses covered with epidermis, with granulation growths, fistulæ of the meatus, and lastly with those malignant new-formations which grow out of the tympanic cavity in the form of polypi. The rapid recurrence after repeated removal of the growth, the simultaneous infiltration of the neighbouring lymphatic glands, especially the microscopic appearances, soon reveal the nature of the growth.

FIG. 279.—POLYPUS OF THE TYMPANIC CAVITY GROWING THROUGH THE PERFORATION.

In a girl aged 16, who had suffered from otorrhœa for one year. Acoum. = 2 m.; whispering = 6 m.

It is of great importance, especially in regard to operations, to determine the place of origin of the polypus, as the procedure varies according as it springs from the meatus, the membrane, or the tympanic cavity. In the case of small or long and thin polypi we are often able, by feeling and moving the growth with the probe, to get a view of the place of origin of its root. When, however, the polypus entirely fills the meatus and only its outer end is visible, finding its root is much more difficult, as it depends on feeling it with the probe. I use a rectangularly curved blunt probe which, in order to measure the distance from the external orifice of the ear, is marked on the anterior end of every 5 mm. The examination is made as follows: the point of the probe is pushed between the polypus and the wall of the meatus, and after passing round the larger circumference of the growth, it is gradually advanced into the deeper parts. When the instrument, at a depth less than the distance of the external orifice of the ear from the membrana tympani, comes against an obstacle which prevents the circular motion of its point, it may be concluded that the obstacle is caused by the root of the polypus.

If, at the examination of an aural polypus, the point of the probe comes against an obstacle at a depth of 16 mm., it is almost certain that the root of the polypus arises in the external meatus; while in cases in which the

obstacle is met with at a greater depth, it is uncertain. By the circular movements of the probe we sometimes can make out, from the distance of the two places at which the point of the probe is impeded in its movement, what the width of the root of the polypus is. The greater this distance is, the broader the root of the polypus. If, on examination, the polypus is very movable, there is likely to be a narrow and thin pedicle. When it is not so movable, the root of the growth will be broader, and its separation will naturally be more difficult than that of the thin-pedicled polypus. Exceptionally a polypus springing from the cavum tympani may be adherent to the wall of the meatus, and may simulate a polypus of the meatus.

With larger perforations of the membrana tympani, where the polypus does not fill the whole opening, it may be followed into the tympanic cavity by simple examination or with a sound. If, however, the polypus is closely surrounded by the edges of the opening and constricted in shape, the differential diagnosis between polypus of the membrane or tympanic cavity is very difficult. It can only be made by removal of the growth when the view of the perforation over the seat of the new growth will positively decide. In a preparation in my collection, on which a tongue-shaped growth appeared to come from Shrapnell's membrane, above the short process the growth extended through a perforation in Shrapnell's membrane, and had its base on the neck of the hammer.

Another guide, but also not a sure one, for ascertaining the point of origin of a polypus, is the external appearance of the growth. The pale-red, pearl-gray polypi with smooth or moderately rough surface, spring usually from the meatus: while the sodden, red, vascular raspberry-shaped growths, with villiform, papillated surfaces, most frequently arise in the tympanic cavity. These peculiarities, however, are only of diagnostic value in connection with the result of the examination with the probe.

The prognosis is more favourable in the case of polypi of the meatus, the radical removal of which can be much more surely effected than in the case of polypi of the tympanic cavity, which frequently recur if their root is situated in the depressions of the tympanic cavity inaccessible to instruments. Circumstances of unfavourable significance are: the repeated occurrence of symptoms of retention of pus, the formation of cheesy masses in the interior of the ear, simultaneous caries in the petrous bone, and the occurrence of pyæmic and cerebral phenomena.

Treatment.—(1) *Operative Treatment.*

a. Extraction is indicated only in the case of those polypi whose origin in the external meatus has been ascertained without doubt.

It is much surer and quicker than the other methods of operation by which the polypus is cut off or ligatured. In the latter case the destruction of the remaining fibrous roots requires a space of several weeks or months, while by extraction the root is removed with the growth, and cure follows after a few days. Moreover, after extraction recurrences are not so often observed as after excision of the polypus with subsequent cauterization of the root.

Before a polypus is removed from the ear the meatus should be cleaned by syringing and filled with a 10 per cent. solution of cocaine by which the operation is made nearly painless.

Extraction of a polypus of the meatus is best effected with Wilde's snare (Fig. 280), it being pushed over the polypus near the root, and

Fig. 280.

only so far tightened as is necessary to catch the polypus securely. A moderate pull generally suffices to remove the growth completely. This procedure is to be preferred to extraction by dressing-forceps, as with the latter the polypus is easily crushed, and only fragments of it are removed. In the case of polypi soft throughout, extraction with the snare is seldom complete, as the soft tissue is easily cut through.

b. Ligature.—When a fibrous polypus is so closely connected with the osseous wall that considerable resistance is shown on strong traction, it is proper to use Wilde's snare to constrict the polypus, the instrument after its loop is tightened being turned on its long axis till a greater resistance is felt. Then the wire fastened to the cross-bar is cut through with scissors, and the instrument removed from the ear. By the twisted wire loop left in the ear the passage of blood to the polypus is stopped, thereby causing its rapid mortification and discharge. This sometimes follows in the first twenty-four hours, and sometimes not for several days, while it is frequently only the peripheral, constricted part of the polypus that is discharged. Only in some few cases have I

Fig. 281.

a, Root; *b*, Place of constriction; *c*, Wire ligature.

observed the simultaneous discharge of the root from the underlying tissues (Fig. 281). If the polypus be not removed at the end of a few days by the use of this wire ligature, by catching the ends of the ligature with the dressing-forceps we may now try to extract the polypus; or in case the obstacle still proves too great, we may increase the twisting of the snare.

c. Excision.—In the case of large polypi, with roots so deep that we cannot with certainty ascertain whether the growth proceeds from the external meatus, the membrana tympani, or the tympanic cavity, extraction, owing to the danger of tearing out one of the ossicles or the cochlea (Toynbee, Böke), is to be avoided, and excision of the polypus should be undertaken.

For this purpose Blake's polypus snare is the best (Fig. 282). It is a movable metal cannula into which the wire loop can be completely withdrawn. Great importance must be placed upon proper wire. An annealed steel wire, 0·1 mm. in thickness, or a thin platinum wire, is the best for this purpose.

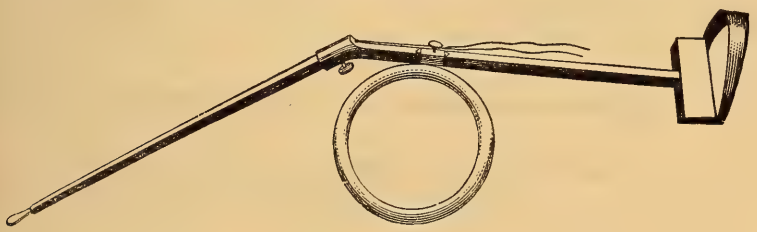

Fig. 282.

A. H. Buck recommends malleable steel wire, No. 37. The oval form of loop is to be preferred to the round. For polypi which spring from the posterior superior wall of the meatus, or from the tympanic cavity, the loop must always be curved downwards before being introduced, so that the anterior section of the loop may glide inwards along the anterior inferior wall of the meatus, and the posterior section along the superior wall. In order to pass the loop more easily over the growth, it is well to push the instrument forwards, not directly, but with moderate rotatory movements.

When the snare has been introduced so that it is near the membrana tympani, the polypus is then cut off by gradually closing the instrument, and removed from the ear with the instrument or by syringing. There is, as a rule, very little bleeding, which may be stopped by repeated injections of cold water. If the bleeding, however, be profuse, the meatus should be stopped with cotton-wool dipped in alum-powder, or with styptic cotton-wool, and the patient should push the plug in with his finger.

After removal of the bulk of the polypus we are in a better position to ascertain whether there are yet other polypi growing in the

interior, how large the remainder of the polypus is, and the seat of the root by probing.

For the removal of intra-tympanic polypi Blake's wire snare with a thinly-made cannula is best adapted. If the perforation is small and the membrane bulged out by the polypus, the former must be widened by an incision in order to allow the instrument to enter the tympanic cavity. The most favourable results are achieved with growths which spring from the inner wall of the tympanic cavity, as the remainder can be easily removed by curetting or cauterizing.

Small soft polypi and granulations in the external meatus or the posterior and lower wall of the tympanic cavity are best removed with the ring-knife which I introduced into use (Fig. 283). The removal with this is more complete than with the wire snare, which bends upon pressing it against the base of the growths.

The instrument, made of steel, which is here illustrated of its full size (Fig. 283), is 7 cm. long, and carries on its anterior end a concavo-convex ring, whose inner margin is very sharp. The diameter of the ring amounts to 3-3½ mm. for large growths, for small granulations and for very narrow

Fig. 283.

meatuses 1½-2 mm. The instrument is attached to the handle (Fig. 119) with a knee-like bend by means of a screw, by which the sharp side of the ring can be turned in any direction. For growths on the lower and posterior wall of the meatus, I use instruments in which the ring is placed at different angles to the long axis of the instrument.

With small, round polypi and granulations in the meatus the instrument is pushed forward to the growth, and its convex surface pressed against the growth till a firm base is felt. The instrument is then quickly withdrawn, cutting the growth from its base and bringing it with it on the concave surface of the ring, and so removing it from the meatus. The growth is anæsthetized with powdered cocaine, applied by means of the moistened end of a probe.

This procedure is suitable also for larger growths with narrow bases. The knife is pushed between the polypus and the wall of the meatus to the place whence it arises, then pressed on the root, which is separated by the quick withdrawal of the instrument.

Polypoid growths on the upper pole of the membrana tympani

may be diagnosed by means of the sound from the handle of the malleus surrounded by granulation tissue. The malleus should also be removed in extensive defects of the membrane, or when it is carious.

d. The *separation* of the growth *by pressure* is effected by a small, roundish, blunt or sharp scoop which is pushed near to the root, and by a quick pressure acting on the polypus from behind, the root is separated from the underlying tissue. This method, however, is only suitable for the removal of thin-pedicled polypi of the meatus not firmly fixed to the subjacent tissue. Thin-pedicled polypi are often separated by brisk syringing and washed out of the ear. Löwe recommends before every operation the trial of removal by strong syringing.

e. Bruising or *crushing* are indicated when large portions of polypi remain on the membrana tympani and on the inner wall of the tympanic cavity, which cannot be removed either by the snare, the

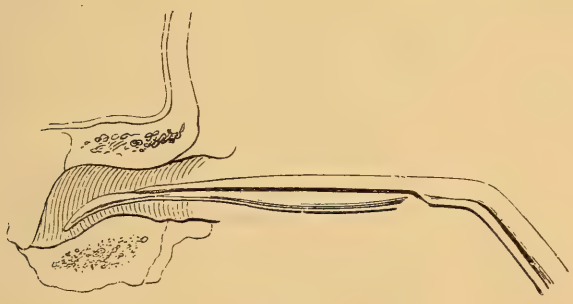

Fig. 284.

annular knife, or the sharp scoop, but which are too considerable to be removed by cauterization or by the galvano-cautery on account of the time it would take.

For this purpose is used small dressing-forceps with a knee-like bend, deeply grooved on their inner surface, the anterior end being either quite straight or, for growths on the inner section of the anterior inferior wall of the meatus, or at the bottom of the tympanic cavity, bent at the edge (Fig. 284). The forceps are introduced up to the growths with the blades closed; they are then opened and pushed so far forward that part of the growth enters the grooved scoop of the instrument, which is then quickly closed, crushing the tissue lying between the blades.

When the bleeding is not too great, this procedure may be repeated several times at one sitting, and the crushing must be continued till nothing can be caught with the forceps, there remaining only a flat part of the growth which can be destroyed by cauterization, or be made to shrink by the instillation of alcohol. Soft remains of polypi in the tympanic cavity which cannot be

fastened with the instrument, sometimes shrink after repeated application of powdered alum, or the introduction of cotton tampons soaked in glycerine and iodine, which exert a pressure upon the growth. When there is profuse secretion of pus in the tympanic cavity, this procedure is contra-indicated on account of the danger of pus retention.

f. Galvano-caustic Treatment.—The cauterization of the remainder of polypi and small granulations with the galvano-cautery is indicated when these cannot be removed by the sharp spoon, or with the ring knife. The cauterization should only be used in growths in the external meatus, on the external surface of the membrana tympani, and on the promontorial wall. Cauterization on the fenestræ of the labyrinth or in the portions of the tympanic cavity which are not visible should be avoided.

The most important advantages consist in the rapid and thorough destruction of the growth, there is almost no inflammatory reaction in the meatus, and the remainder of the growth shrivels much quicker than after other methods of cauterization. Also here the growth should be anæsthetized by applying cocaine powder before it is cauterized.

Fig. 285.—Galvano-Cautery (½ size).

The number of applications of the galvano-cautery varies always according to the size and consistency of the growth. Small soft granulations often disappear after cauterizing once or twice. The remainder of hard polypi must be repeatedly cauterized before they are completely destroyed. The galvano-cautery snare, after the use of which cicatricial strictures of the meatus have been seen, should only be used in exceptional cases with fibrous growths, or those which cannot be removed by other means.

For this purpose a simple pointed cautery is sufficient in most cases; but for large growths, or those extending over a surface, flat cauteries rounded in front, and which can be moved in all directions, are to be preferred (Fig. 285).

The circuit is only to be closed when the cautery is in contact with the growth, and after the occurrence of a loud hissing noise the circuit must be again opened in a few seconds. As the cauterization evolves a very warm vapour which affects the walls of the meatus, it is advisable, immediately after every application, to disperse the vapour by blowing into the ear. Before repeating the cauterization the cautery must be thoroughly heated. Cauterization may be repeated four or five times at one sitting.

(2) *Treatment by Medicated Applications.*

a. Destruction of Polypi by Caustics.—Solid nitrate of silver is used melted in the form of a small ball, the size of a hemp-seed, on the point of an angularly-curved steel or silver wire. Cauterization with nitrate of silver without exception occasions pain lasting for a long time after the effect of the cocaine has passed off, and, moreover, has the disadvantage of forming only a superficial crust, and very often before that is cast off just as much new-tissue grows as was destroyed by the caustic.

Perchloride of iron acts much more favourably, rarely gives rise to violent pain, penetrates much deeper into the tissue even in hard fibrous growths, and brings about mortification and separation of the dead parts much more quickly.

Chloride of iron is most simply applied by means of a probe dipped in the fluid, or by means of a small brush or ball of wadding. The cauterization is repeated when the crust is loosened by syringing. For hard growths I have of late frequently used the crystals of chloride of iron. In order to localize its action and to protect the normal parts of the walls of the meatus, a small piece of it is taken hold of with the forceps and rapidly introduced up to the growth and fastened there by a plug of cotton-wool applied to the neighbouring wall of the meatus. The rapidly melting chloride of iron penetrates into the tissue and, without causing any great pain, forms with it a crust. The crystals of sesquichloride of iron are particularly recommended for hard growths which, involving the real circumference of the osseous meatus, at last, by coming into contact, fill up the lumen of the meatus, so that the probe cannot penetrate between the growth and the wall of the meatus or at any other place. The removal of such growths by operative treatment is accomplished with great difficulty, as the separation of the masses from the meatus is usually accompanied with profuse bleeding, which after the first incision prevents the completion of the operation.

Vienna paste, potassa fusa, and nitric acid, as recommended by Trampel and A. H. Buck, have been rightly discarded, as their action cannot be confined to the polypus, and caries of the osseous meatus may be produced. The hard paste of zinc chloride, morphia and meal, as proposed by Lacharrière, can be used with more certainty, as well as chromic acid, which occasionally produces severe pain. Lucae recommends cauterizing with cupric sulph., or with a mixture of alum and pulv. herb. sabinæ. Before and after the cauterization, the meatus should be filled with a 10 to 15 per cent. solution of cocaine.

b. Alcoholic Treatment.—Rectified spirit of wine has in a great number of cases proved of excellent service for the removal of aural polypi and granulations, and is specially suited for :

1. Removing the remains of polypi in the external meatus and on the membrana tympani.

2. The treatment of intra-tympanic polypi, which, as we have seen, can seldom be entirely removed by operative means, and frequently recur.

3. Multiple granulations in the external meatus and on the membrana tympani.

4. Diffuse, excessive proliferation of the mucous membrane of the middle ear.

5. Cases in which, on account of mechanical obstruction in the meatus (exostoses, strictures, etc.), the removal of polypi cannot be effected with instruments.

6. Avoiding operations in persons afraid of them, in whom surgical treatment meets with great difficulties.

The alcohol treatment is contra-indicated in painful inflammation of the meatus, when caries is suspected, and in cases in which, after its instillation, severe pain, headache, dizziness, or nausea occur.

Before the use of the alcohol the ear must be carefully cleaned, and dried with a plug of cotton-wool. After this the warmed alcohol is poured into the meatus, and left for at least 15 to 30 minutes. Where the concentrated alcohol cannot be borne, it is better to begin with a solution containing $\frac{2}{3}$ or $\frac{1}{2}$ water, and gradually increase to the strong concentrated alcohol. The instillations should be repeated once or twice a day, and continued without interruption until the polypus has completely disappeared. The duration of treatment varies from 2 to 6 weeks or longer.

By this treatment will not only the remainder of polypi and granulations be shrivelled up, but also large fibrous polypi filling the external meatus may be destroyed. The effect of the alcohol upon the extent of the polypus is often manifested only after its use for 2 to 3 weeks. From the time when the diminution in size is first manifest, the shrinking progresses very rapidly.

The advantages of alcohol over the previously named caustics are that its effect is much more certain and less painful, and that it forms no precipitate with the secretion to produce an injurious effect afterwards. The alcohol treatment may be used by every practitioner, and operative treatment or the use of caustics is rendered unnecessary in many cases. As the alcohol treatment is of long duration, in those cases where it is possible the greater portion of the polypus should be removed by operation, in order to shorten the time, and then alcohol used to produce shrinking of the remainder. I have never seen unpleasant accidents during the alcoholic treatment.

Among the rare growths in the sound-conducting apparatus must be mentioned enchondroma, originating in the cartilage of the meatus (Launay,

Gaz. des Hôp., 1861), the thorn-shaped chondroma seen by me on the anterior osseous wall of the meatus (Fig. 286), which was removed with the instrument used for cutting through the long process of the incus (Fig. 239); the chondro-myxoma of the cartilage of the ear (Haug), the osteoma of the mastoid process seen by me in two cases, in one case half the size of a walnut, in the other the size of a walnut, extending above the process, with sharply marked edges and closing the meatus by bulging its posterior wall forward. Weinlecher (*M. f. O.*, 1887) removed an osteoma the size of a hen's egg from the mastoid process of a woman in whom the growth occurred without any disturbance. The middle-ear suppuration, which occurred after the operation ceased without leaving further disturbance.

FIG. 286.—THORN-SHAPED CHONDROMA IN THE OSSEOUS MEATUS OF A MAN AGED 22.

To these should be reckoned the cylindroma or myxoma cartilagineum of the cartilaginous meatus (Meckel, v. Hemsbach), the adenoma of the sebaceous glands in the external meatus (Klingel), lipoma on the auricle, and pedunculated papilloma on the upper wall of the meatus with a normal covering of skin. I observed a case of psammoma of the dura mater, the size of a hazel-nut, which was seated above the tegmen tympani, and penetrating, by pressure, into the middle portion of the tympanic cavity, bent the tensor tendon downward. Miot (*Revue mens.*, 1886) extirpated a hard connective-tissue growth the size of half a hempseed from the handle of the malleus.

Among these we must also class those sarcomata, known as atypical connective-tissue tumours, which in the majority of cases present the malignant characters of the carcinoma. Roudot (*Gaz. méd. de Paris*, 1875) observed a sarcoma the size of a walnut occupying the lobe and tragus, which developed within twenty years, and was removed by total extirpation. An interesting case of round-celled sarcoma of the middle ear has been described by Hartmann (*Z. f. O.*, viii.). In a boy three and a half years of age there developed, within fourteen days after an acute suppuration of the middle ear, polypous growths in the tympanic cavity, which always recurred, notwithstanding repeated removals and galvano-cauterization. Gradually there formed a diffuse tumour in the region of the ear, the elements of which proved after incision to be those of an ulcerating round-celled sarcoma. Death occurred five months later. Orne Green (*Arch. f. Otolog.*, vol. viii.) reported a round-celled sarcoma growing from the carious wall of the osseous meatus. Haug (*A. f. O.*, vol. xxx.) reported a myxosarcoma of the tympanic cavity and mastoid process in a girl aged 18. Stacke and Kretschmann (*A. f. O.*, vol. xxii.) report a spindle-celled sarcoma on the auricle which resembled a polypus, and was observed by Robertson (*Transact. of the Am. Otolog. Society*, 1870).

Of mixed sarcomata, the osteosarcoma, springing from the middle ear, has been observed in four cases by Wilde (*l. c.*), Wichart, and Böke (*W. med. Halle*, 1863).

Some pathological formations in the sound-conducting apparatus, not

strictly classed with the new-formations, might find a place here; for example, the so-called retention-tumour; the milium in the external meatus; atheroma and cysts on the auricle. The latter, seated on the posterior surface of the auricle (Gruber), may reach an enormous size. In a case observed by me the tumour was twice the size of the auricle, and after being opened discharged a yellowish fluid mixed with gritty particles. After partial excision of the follicle and of the cutaneous covering, cicatrization was brought about by repeated cauterization of the wound with solution of nitrate of silver.

There must further be mentioned partial ossification of the auricle, observed by Gudden and Bochdalek; ossification of the inferior cartilaginous wall of the meatus, observed by Jos. Pollak; calcification and the deposition of urates in the cartilage of the ear of gouty patients (Garrod); and the syphilitic gummatous tumour on the mastoid process, first described by Jos. Pollak in the case of a man thirty-nine years of age, who was ultimately cured (*Allg. Wien. med. Ztg.*, 1881).

2. *Epithelial New-formations.*

The starting-point of the epithelial new-formation is most frequently the auricle and the external meatus, less frequently the tympanic cavity and the mastoid process. On the auricle the epithelioma is usually developed in the cutis on the upper part of the helix, and spreads from there at first gradually, then very quickly over the greater part of the auricle, the cartilage of which is ulcerated in various places and perforated. In one of my cases, in which cancer commenced at the posterior point of attachment of the auricle, the inner section of the concha was so completely destroyed that the auricle was suspended above and below by two narrow strips of skin.

If an epithelioma of the auricle is not excised at the proper time it spreads, involving the side of the head and neck and the external auditory meatus, then the middle ear, the rest of the bones of the head and the cranial cavity. The destruction of the cranium, extending up to a fatal termination, reaches such an extent that not only is the middle ear exposed, but also deeper lying parts of the skull.

In a case communicated by Ch. Delstanche (*A. f. O.*, xv.), and which I had an opportunity of seeing, the growth proceeding from the inner surface of the right tragus extended so far that the tympanic cavity and the Eustachian tube, the posterior part of the frontal bone, the wing of the sphenoid bone, and the posterior orbital wall were destroyed and exposed. Symptoms accompanying this destruction were facial paralysis, exophthalmos, amaurosis, loss of taste and smell, and paralysis of the right palatine muscles. Death resulted from the extension of the cancer to the dura mater.

In the case of a woman, sixty-four years of age, observed by me, in which an epithelioma of the right auricle involved the external meatus, and death resulted from exhaustion, on microscopic examination I found the greater part of the lining membrane of the meatus infiltrated with cancer-cells. These cells were more especially accumulated at the place where the meatus adjoined the membrana tympani; smaller infiltrations were found in the cutis of the membrana tympani and on its mucous membrane. A point of

interest was the occurrence of numerous cancer-cells in the osseous spaces of the temporal bone distant from the primary deposit, a circumstance which explains the fruitlessness of operative treatment in many apparently local and circumscribed growths.

The treatment of epithelioma of the auricle depends on its extent. If it be confined to a circumscribed part of the cutis, treatment is limited to destruction with lunar caustic or zinc paste, or to scraping it off with the sharp spoon, and subsequent application of fuming nitric acid. For a case of very extensive ulceration, partial or complete amputation of the auricle is recommended. The latter operation is always determined upon before the growth has reached the external orifice of the ear, as then it is of no avail, on account of invasion of the neighbouring parts and of the lymphatic glands by the cancer-cells having already commenced. In one of my cases in which, on account of carcinomatous destruction of the external half of the cartilage of the ear, the whole auricle, up to the external orifice of the ear, was amputated, cure resulted without any recurrence, and the defect was concealed by an artificial auricle of flesh-coloured india-rubber, made in Paris.

Epithelioma of the external meatus is developed with symptoms of a moist eczema, or with the formation of a circumscribed crust, which is frequently scratched on account of the great itching till ultimately the surface becomes ulcerated, the ulcer growing outwards towards the auricle and downwards towards the membrane. Sometimes the appearance of the growth is preceded by great pulsating pains and a limited loosening of the wall of the meatus, where, after some weeks, an ulcerated, red-spotted, and secreting surface with jagged edges is formed. Besides the spongy growths there are depressed places on which the white cartilage of the ear and the osseous wall of the meatus are laid bare.

Epitheliomas of the meatus usually end by extending to the middle ear and labyrinth and from there to the cranial cavity, producing paralytic and meningeal symptoms, ending fatally after long-continued pain, facial paralysis, and ulcerating infiltration on the external region of the ear.

According to the observations of Schwartze, Lucae, Kidd and others, epitheliomata proceeding from the middle ear arise either during an existing suppuration of the middle ear or after exhaustion of carious processes in the temporal bone. For this reason the growths protruding through the perforation of the membrana tympani are at first taken for granulations or polypi, till their rapid recurrence after repeated removal and their microscopic appearances reveal their malignant nature. The course is characterized by intense pain, facial paralysis, profuse hæmorrhages, and infiltration of the lateral cervical glands, and is usually followed by a fatal result from meningitis, abscess of the brain, or sinus-thrombosis.

Sometimes malignant growths from neighbouring organs invade the temporal bone. Knapp (*Z. f. O.*, xi.) speaks of a case of chrondro-sarcoma of the parotid, which invaded the tympanic cavity notwithstanding early extirpation, and formed an immense growth involving the whole sound-conducting apparatus. Pomeroy (*Am. Journ. of Otol.*, iii.) observed a case of intercranial myxosarcoma, which, proceeding from the middle and posterior cranial fossæ, protruded, after destruction of the petrous bone, into the

tympanic cavity and the external meatus, and ended fatally with brain symptoms.

The extension of epithelial cancer of the tongue and of the upper jaw to the Eustachian tube has been observed by me in five cases. These, during life, presented on the affected side the signs of otalgia and closure of the tube; in one case a serous accumulation was found in the tympanic cavity. The tuning-fork on the vertex was always better perceived on the affected side.

The post-mortem examination showed in all the cases an extension of the growth from the upper jaw to the basilar fibro-cartilage and to the connective tissue surrounding the cartilaginous Eustachian tube. The whole tube appeared imbedded and compressed in its fatty, infiltrated surroundings. In microscopic sections, the epithelial new-formation is seen in the form of cones and nests filled with compressed epithelial cells, and in some preparations as cancroid nodules reaching close to the cartilage of the tube. The latter itself is not affected at any part by the cancerous matters. In the membranous portion of the tube, on the other hand, scattered cancerous nodules are found, which, however, do not reach to the epithelium. In addition, the glands of the mucous membrane of the tube show great dilatation.

Neuroses of the Sound-conducting Apparatus.

1. *Otalgia.*

Nervous otalgia is caused either by an affection of the sensory nerves of the external and middle ears, or by disease of the nerve-trunks supplying the organ of hearing. Not unfrequently, pain in the ear has its origin in other parts of the body, as the teeth or larynx.

Otalgia occurs either as a localized ear-disease or as one of the phenomena of a trigeminal or cervico-occipital neuralgia.

Neuralgia of the auricle is rare, and usually limited to a circumscribed part. On the anterior surface it is due to an affection of the trigeminus (N. auriculo-temporal.), on the posterior surface to an affection of the superior cervical nervous plexus (N. auricular. magn. et occipital. minor). Besides the painful point on the auricle, there is often another found on the mastoid process (Valleix's mastoid point). The pain is increased by a light touch or pressure; sometimes, however, it is diminished by stronger compression. Occasionally a slight congestion and swelling of the affected part occurs.

Otalgia of the external meatus can only be recognised as such by localizing the pain in the cartilaginous section; when the pain is seated deep down in the osseous portion, it is not possible to distinguish between otalgia of the auditory meatus and otalgia of the middle ear.

Neuralgia of the tympanic plexus, which consists of branches of

the trigeminus, sympathetic, and glosso-pharyngeal nerves, occurs either as a local neurosis or as a symptom of an affection of the third, more rarely of the second branch of the fifth. In the latter case the otalgia is limited to the middle ear, while in the former the external and middle ears are both affected. Rarely the mastoid process is the seat of a severe nervous pain which occurs in adhesive processes and suppuration of the middle ear.

The chief causes of otalgia are: cold, anæmia, hysteria, neurasthenia, sexual derangements, perineuritis of the nerve-trunks, pressure on them in their course, hyperæmia, inflammation and new growth in the Gasserian ganglion, tumours of the brain, caries of the cranial bones and of the cervical vertebræ, and the effect of severe noises. Several times I have observed persistent otalgias in carcinoma of the superior maxilla and the retropharyngeal region; it is described as an early symptom of cancer of the tongue by Richard, especially in children. Among the most frequent causes of otalgia are carious teeth, ulcers in the larynx (Gerhardt) and in the neighbourhood of the pharyngeal orifice of the Eustachian canal.

The attacks are characterized by intense rending and piercing pains in the interior of the ear, which seldom last longer than a few hours, and return generally at irregular intervals. Sometimes otalgia shows a markedly periodic character.

The occurrence of what was called intermittent otalgia by the earlier writers has been observed in recent times by Voltolini, Weber Liel and Orne Green. The last-named, in a patient with intermittent fever, observed during every attack, in addition to neuralgia in the area of the trigeminus, the occurrence of symptoms of an acute inflammation of the middle ear (otitis intermittens) which receded with the paroxysms of fever. Intermittent otalgia is to be referred to malarious infection (Intermittens larvata) only when a splenic tumour is present.

During an attack of otalgia there are often subjective hearing-sensations and deafness, hyperæsthesia acustica, and not unfrequently also hyperæsthesia of the skin of the auricle and of the temple, which disappear after the attack. Loud noises near the patient increase the pain in many cases.

The course of otalgia is acute or chronic. In the former case, the neurosis lasts for a few days or weeks with irregular, rarely regular, intervals. The course of chronic neuroses is quite uncertain; the attacks often occur at intervals of weeks or months, and the disease may last for years. Chronic otalgia with a distinctly periodical course is rare. In one of my cases the attacks occurred for ten years, regularly every month or every second month on the left side, ending after several hours' duration in a sound sleep. The

course of radiating otalgia, or that combined with neuralgia of the trigeminus, depends upon the course of the original disease.

The diagnosis of otalgia and its distinction from an inflammatory pain result from the absence of inflammatory signs in the ear. When a case has been decided as otalgia, it must next be determined whether it is a local neurosis or one of the phenomena of a trigeminal or cervico-occipital neuralgia, or lastly, part of a radiating pain in the ear. The teeth must then undergo minute examination; when there is caries, that may be taken as the probable cause of the otalgia when by pressure on the diseased tooth violent pain is caused. If symptoms of a pharyngeal or laryngeal affection be present, it must be ascertained by a minute examination with the speculum whether the pain proceeds from ulcers in the pharynx or larynx.

The connection of otalgia with neuralgia of the fifth nerve and of the cervical plexus may be ascertained by examination of the known painful points (points douloureux). In affections of the trigeminus the pain is either general or only at a few spots. The otalgia is frequently so prominent, that it is only by ascertaining the painful points that the existence of an extensive neurosis of the trigeminus is discovered.

The prognosis of otalgia is generally favourable in recent cases and in the periodic forms, even when the affection is one of the signs of trigeminal neuralgia. Further, the prognosis is altogether favourable when the otalgia is due to a carious tooth. It is, on the other hand, unfavourable in the lingering neuralgias of the fifth nerve, especially when the cause lies in a cerebral affection or in an irremediable compression of the affected nerve-trunk. Other unfavourable circumstances are anæmia and marasmus, inveterate syphilis, and tubercular ulcers in the larynx, and carcinoma in the region of the Eustachian tube.

The treatment is governed by the cause and the duration of the disease. When dental caries is recognised as the cause of the suffering, the patient should be sent to the dentist. In recent otalgia, localized or associated with neuralgia of the fifth nerve—whether the attacks occur irregularly or periodically—sulphate of quinine is used (3 to 8 grm. three times daily). In the periodic form the quinine (4 to 8 grm. doses) is given two or three times in the course of two or three hours before the attack. The action of quinine is often assisted by the addition of iodide of potassium (1 of quinine to 2 of the iodide).

The iodide of potassium in larger doses is specially indicated when there is a suspicion of syphilis, and when contractions and slight paresis of the muscles of the face occur together, in which

case the earache is probably caused by inflammation of the Fallopian canal. During severe attacks it is often necessary to alleviate the pain by the internal or hypodermic use of morphia.

In the chronic forms treatment has seldom any considerable results; sometimes, however, by the use of one or other remedy the attacks become milder and less frequent. The most commonly employed internal remedies are quinine, iodide of potassium, iron, arsenic (Fowler's sol.), salicylate of soda, Ol. terebinth., atropine (5 gtt. of a 1 per cent. sol.), oxide of zinc, the latter either alone or in the form of Meglin's pills (zinc. oxid., rad. valerian., extr. hyoscyam. nigr. āā. 10·0; ft. 100 pills; the dose to be gradually increased from 1 to 30, and then gradually diminished), and antipyrine (1 to 2 grm. per die).

Of external remedies, vesicants to the mastoid process have proved effectual, as have also the endermic inunction of morphia or veratrine ointment, and narcotic plasters. Both in the obstinate acute and in the chronic forms galvanic treatment is indicated, as it very often effects an improvement when all other means fail. In applying galvanism, according to Erb, the copper pole is to be placed on the ear and the zinc pole on the neck. The Faradic current is not to be recommended, on account of the frequent simultaneous hyperæsthesia of the skin.

In cases in which the pain affected the whole region of the ear, and was increased upon pressure especially between the ramus of the jaw and the mastoid process, corresponding to the course of the cartilaginous Eustachian tube, after repeated massage I have observed considerable improvement, and even complete disappearance of the otalgia after some days. In neuralgias of the mastoid process which cannot be alleviated, when the cause is supposed to be excessive connective growth, the chiselling away of a piece of bone is indicated. In a girl, aged 18, in whom after the opening of the mastoid process had healed, a neuralgia of the cicatrix remained for a year, accompanied by depression and melancholia, it completely disappeared after chiselling out the sclerosed portion of bone.

Sometimes in hemicrania a dull pain arises in the ear and in its neighbourhood, accompanied with hyperæmia and a feeling of heat and burning on the auricle and temple. Eulenburg and Möllendorf, who term this form hemicrania angio sive neuroparalytica, trace it to an affection of the sympathetic nerve.

The rarely occurring hyperæsthesias and anæsthesias of the auricle and external meatus belong to the neuroses. Hyperæsthesias of the auricle often remain after freezing, inflammation, and eczema.

Many persons are specially sensitive to the effect of cold draughts or wind, so that it is necessary for them to wear a plug of cotton in the ear as a protection. Narcotic applications do not diminish the sensitiveness. On the other hand, methodical, cold rubbing of the external region of the ear, painting with fat and electricity, sometimes have a good effect. That also nervous itching of the skin (pruritus) may occur, has already been mentioned in speaking of the anomalies of secretion in the meatus. The trouble is often very irritating, and conduces to excoriations and inflammation from the intense scratching. Painting with oleum vaselini or with β-naphthol 0·2, alcohol and ether sulph., āā. 10·0, often lessen the itching for a long time. Severe attacks may be rapidly stopped by a 20 per cent. sol. of cocaine.

Anæsthesia of the nerves of the ear affects most commonly the auricle, especially the expansion of the fifth nerve on its anterior surface. It seldom occurs as an independent affection, but more frequently as one of the phenomena of a diminished sensibility of the affected half of the head, especially in cerebral diseases, hysteria, brain tumours, after cerebro-spinal meningitis, and after the effect of severe noises.

Anæsthesia of the external meatus is little known. On the other hand, as I have elsewhere mentioned (*W. m. W.*, 1863), a decrease in the sensibility of the mucous membrane of the middle ear, especially in the chronic adhesive processes without secretion, is by no means uncommon.

2. *Motor Neuroses.*

Under this heading are to be ranged:

1. *Spastic Contractions of the Muscles of the Auricle*, which are most frequently a part of a facial spasm (tic convulsif), less often an independent neurosis (Romberg).

2. *Spastic Contractions of the Intrinsic Muscles of the Ear.*—The observations hitherto recorded, relate to spastic contractions of the tensor tympani, and must not be confounded with voluntary movement of it. They may be recognised either by a distinctly visible movement on the membrana tympani or by inserting a manometer into the meatus, in which at every contraction of the muscle a negative oscillation of the enclosed fluid will be seen. The contractions manifest themselves subjectively by a loud cracking sound which is objectively perceptible, or by a dull throbbing in the ear. The hearing-tests applied by me in one case showed that during the contractions the hearing-distance is diminished, deep tones

become deadened and indistinct, and high ones ascend about one quarter of a tone.

From the fact that during strong contractions of the orbicularis palpebrarum contractions of the stapedius are set up, Gottstein believes (*A. f. O.*, xvi.) that in a case of blepharospasm observed by him, in which during the attack a rushing noise was heard in both ears, the latter was caused by a clonic spasm of the stapedius. Habermann did tenotomy of the stapedius in a case in which subjective noises, dizziness, and fulness of the head occurred with clonic spasms of the stapedius muscle, after which these symptoms stopped. Bürkner alleviated the blepharospasm by catheterization in a case where it accompanied roaring and hammering in the ear.

3. *Clonic Spasm of the Muscles of the Eustachian Tube*—This has been observed by Schwartze, Brunner, Todd, and myself in a few cases. In two of my cases the cracking sound caused by the contractions of these muscles was like the irregular ticking of a watch a great distance off, continued during sleep, and could not be suppressed by efforts of the will. At every sound a corresponding contraction could be perceived on the velum palati. The noise stopped when the velum palati was raised with the finger. Rüdinger observed autophonia in himself during contraction of the muscles of the tube. In a case of Schwartze's the affection was combined with spasm of the muscles of the larynx, eyes, mouth, and nose. Galvanization of the soft palate and massage of the region between the ascending ramus of the inferior maxilla and the mastoid process have proved the best therapeutic means.

Injuries of the Sound-conducting Apparatus.

Lesions of the auricle are classified according as they are caused by stabs, blows, cuts, tears, or contusions. Their importance depends on the severity of the wound and on the extent of the injury. Superficial bruises confined to the skin always heal without visible consequences, while deep-seated lesions affecting the perichondrium or the cartilage, as we have seen in othæmatomata, have as their consequence severe hæmorrhage, inflammation, and deformity of the auricle. The course of incised wounds of the cartilage of the ear, as occurring in fights, duels, etc., is most favourable, in so far as even in large breaches of continuity (v. Tröltsch, Trautmann), after the edges of the incision have been united by means of the interrupted suture, in the most cases healing by first intention occurs. Less favourable are the terminations

of tears, bruises, and bites,* as after sloughing of the injured cutis ulcers may form from exposure of the cartilage, the cicatrization of which is generally associated with shrinking and deformity of the auricle (Kirchner).

Injuries of the external meatus affect more frequently the osseous than the cartilaginous section. Lesions of the cartilaginous meatus are either confined to itself or combined with those of the auricle. In one of my cases there occurred, in consequence of a fall, a fracture of the inferior wall of the cartilaginous meatus with great bleeding at the ear, which healed without suppuration. The lining membrane of the cartilaginous section, seldom the cartilage itself, is very frequently injured by rough attempts at extraction of foreign bodies, without deep-seated changes remaining behind.

Injuries of the osseous meatus may be caused by direct or indirect violence. Direct injuries affect either the lining membrane of the meatus alone or the osseous wall as well. Here also violent attempts at extraction of foreign bodies must be looked upon as amongst the chief causes. Then the meatus is often injured by solid objects introduced to scratch it in severe pruritus, often indeed from the fact that while scratching the arm is accidentally pushed and the instrument is driven against the wall of the meatus. Cassells (*Glasg. Med. Journ.*, April, 1876) records a case of injury at the place of union of the cartilaginous and osseous sections from the stab of a steel pen, causing not only traumatic otitis externa, but also inflammation of the mastoid process. Limited fractures of the osseous meatus from direct violence are very rare.

Fractures of the external meatus from indirect violence are much more frequent; they are due either to fractures of the skull caused by blows, kicks, or falls, extending to the walls of the meatus, or to injuries caused by violent blows on the lower jaw, by which its articular process is driven with great force against the wall of the meatus.

The locality of the lesion depends on the site of the injury. Violence on the top of the head usually causes fissure of the superior wall of the meatus; on the back of the head, fissure of the posterior wall of the meatus; and a blow on the lower jaw causes injury of the anterior wall. On the latter, by indirect violence, not only do fissures arise, but also comminuted fractures, so that pieces of bone may be discharged or extracted from the meatus (Jakubasch, *M. f. O.*, 1878; Trautmann, *A. f. O.*, xv.; Kirchner, *Verh. der phys.-med. Ges.*

* According to E. Hoffmann (*Lehr. der gerichtl. Med.*, 1881) the auricle is frequently bitten off in the Tyrol, as he in a seemingly short space of time had three such cases to treat.

in Würzb. N. F., vol. xvi.). Burnett (*Am. Journ. of Otol.*, vol. ii.) observed in three cases caries and necrosis of the injured anterior wall of the meatus after accidents to the lower jaw. Kirchner affirms, moreover, that from injuries to the lower jaw inflammations of the lining membrane of the meatus and of the middle ear may arise without fracture of the osseous walls of the meatus.

The terminations of fractures of the meatus are either recovery without subsequent deformity, or caries and necrosis of the affected wall with exfoliation of sequestra and permanent stenosis. Fissures on the posterior wall lead to traumatic inflammation of the mastoid cells, which may end fatally by complication with thrombosis of the sinus. In like manner fissures on the superior wall may terminate fatally from meningitis, when the dura mater has at the same time been injured. Fractures of the anterior wall may, after previous suppuration, end with the formation of osteophytes (Wagenhäuser).

In a case observed by me a fissure was made in the superior wall of the left meatus by a blow on the left side of the vertex, which healed with a depression on the bone without leaving any disturbances, while by contrecoup concussion of the right labyrinth resulted with permanent deafness.

On the whole fractures are seldom confined to the meatus, but are usually complicated with fissures of the superior and inner walls of the tympanic cavity, of the mastoid process, of the pyramid of the petrous bone, and of the base of the skull. In the majority of these cases the membrana tympani is ruptured, and the injury is accompanied by profuse bleeding. If the fissure extends to the capsule of the labyrinth, or to the cranial cavity, there results with symptoms of headache, dizziness, vomiting, tinnitus, and severe deafness, an abundant serous discharge from the ear, which possesses the chemical properties of the cerebro-spinal fluid. The fluid flows through the ruptured membrana tympani, or, as in a case of Zaufal's, where the membrane remained intact, through a fissure in the superior wall of the meatus. Where the chorda tympani is injured through the fracture the sensation of taste will be wanting on that half of the tongue.

Complicated injuries of the latter kind terminate, as a rule, fatally by the occurrence of meningitis. Healing is only rarely seen (Schroter). The possibility of recovery, even in cases with serious clinical symptoms, must not, however, on that account be excluded.

Schwartze (*A. f. O.*, xvii.) describes a case in which the labyrinth was injured with a knitting-needle and recovery occurred. Körner (*A. f. O.*, xvii.) records a case of gunshot-wound, with fracture of the wall of the labyrinth, accompanied by a discharge of cerebro-spinal fluid. Recovery took place in

five weeks without the projectile having been removed. A case of fissure of the pyramid (by a blow from the shaft of a cart) with discharge of cerebro-spinal fluid, which ultimately recovered, has been related by Trautmann (*A. f. O.*, xiv.). In a case reported by Daake, deafness and facial paralysis resulted from fracture of the skull. After his death, seven months later, from tuberculosis, the autopsy showed a healed fissure which extended to the pars tymp.

An interesting case of gunshot-wound of the Eustachian tube is related by O. Wolf (*A. f. A. u. O.*, ii.). The projectile entered beneath the zygomatic arch through the left superior maxilla into the tube, and remained wedged there. There were present symptoms of occlusion of the tube, a highly concave state of the membrana tympani, deafness and subjective noises, which were only temporarily improved by repeated paracentesis of the membrane. Wolf also describes a case of injury to the petrous portion of the temporal bone by a shot, which he succeeded in removing from its posterior portion immediately against the transverse sinus, by loosening the auricle and chiselling away the posterior wall of the meatus. Complete healing followed.

Bezold (*Berl. klin. Wochenschr.*, 1883) reported a case of a stab wound on the side of the neck, by which the tube was cut through and atresia resulted. This case is of special interest from a forensic view, as the patient was suspected of simulation.

In a case observed by me, in which the projectile penetrated the parotid, the meatus, and the mastoid process, and reappeared at the posterior portion of the latter, the sequelæ of the injury were stricture in the middle of the meatus, a salivary fistula discharging into the external meatus, and facial paralysis.

Cassells (*Glasg. Med. Journ.*, viii.) saw a girl seven years of age, who, from a kick from a horse on the right side of the head, received a fracture of the mastoid process communicating with the meatus, out of which gushed a stream of blood as thick as a finger, very probably from the lateral sinus. Recovery resulted after exfoliation of several splinters of bone.

To the rarer injuries of the hearing-apparatus belong fractures of the handle of the malleus. They are caused by direct violence on the membrana tympani, the introduction of hard bodies into the meatus, severe blows on the skull, jumping from a great height, and by the extraction of foreign bodies, and may either heal by formation of callus, or remain ununited. In both cases the lower broken end forms an obtuse angle with the upper end of the handle (Roosa). On examination with Siegle's speculum the lower end of the fracture seemed to move outwards, while the upper portion of the handle remained immovable.

Among the mechanical injuries of the sound-conducting apparatus are reckoned those caused by thermic and chemical influences. By the penetration of hot fluids into the ear, the walls of the meatus are much less affected than the membrana tympani, in which (Bezold, *A. f. O.*, xviii.) there remains, after a protracted suppuration of the middle ear caused by the scalding, a persistent perforation of the membrana tympani. Opitz found, among recruits, the formation of eschars in the meatus due to the entrance of the hot vapour of burning wax and tallow; Weintraub, cauterization of the car-

tilaginous meatus by solid nitrate of silver, resulting in stricture. Cases of burning through pouring molten lead into the meatus, with deafness and permanent facial paralysis remaining, or a fatal result from meningitis, have been reported several times in the literature of otology.

Among injuries by chemical agents must be mentioned: cauterization of the ear with nitric and sulphuric acids, with liq. ferri sesquichlor., with caustic alkalies, nitrate of silver, chloroform, and ether.

As results are mentioned: destruction of the membrana tympani with exfoliation of the ossicula, caries of the walls of the meatus and tympanic cavity, facial paralysis, polypi, persistent perforations, adhesive processes, and the fatal result.

For giving a medico-legal opinion as to lesions of the sound-conducting apparatus there are no general rules, as the injuries are so varied that scarcely ever are two cases alike. Therefore, in estimating the lesion, it is necessary to consider the nature of the violence in the given case and the extent of the injury, and to pay particular attention to the result of the latter.

The medical profession, in judging of injuries of the ear, generally proceed in the same way as in the case of other injuries, *i.e.*, according to §§ 152 and 156 of the Austrian Penal Law, and to discuss separately:

1. Whether the injury causes a disturbance of the health (disease, in the vulgar sense) or incapacity for business, and how long the former or latter has continued.

2. Whether the injury was severe. Later indications will be passed over when the clinical symptoms were serious, or when noteworthy effects remained.

If the latter is the case, further explanation is required—(*a*) Whether, in the case of a secondary deformity, it is to be regarded as 'permanent' and 'striking' in the sense of § 156; and (*b*) whether, when a disturbance of the hearing ensues, it is to be regarded as 'loss' or permanent impairment of hearing,' in the sense of the same law.

The judgment of the injury will be modified if a slight injury has a deleterious effect upon a previously diseased ear. As in the case reported by Heimann (*Z. f. O.*, xx.), in which, owing to existing caries of the temporal bone, a blow on the ear resulted fatally from meningitis. For such cases the judge, owing to the consideration of the 'peculiar bodily constitution' of the injured, should be cautious in taking into account the diseased condition of the ear, which was not known to the person who inflicted the injury, and the results of which were not due to the injury itself.

In estimating injuries of the auricle, deformities of it resulting from lesions are particularly considered. Contusions, stabs, and blows, even extensive disturbances of its attachment, which, as we have seen, may heal by first intention, are to be regarded as slight injuries, as they do not leave behind any remarkable change in the form of the organ. On the other hand, all injuries by which, in consequence of inflammation, breaking down, necrosis, and exfolia-

tion of the cartilage and shrinking and deformity of the auricle occur, are to be termed serious on account of the disfiguration ; and it has still to be decided whether the latter is to be considered 'permanent and striking' in the meaning of the Penal Law, as in that case a sharp punishment is imposed.

The estimation of lesions of the external meatus depends upon whether the injury is confined to its lining membrane alone, or causes at the same time a fracture of its osseous walls. In the former case the injury will be called slight on account of the favourable termination. With fracture of the bone, on the other hand, particularly with splintering of the anterior and fissure of the posterior wall, the injury will in so far, on account of the consecutive inflammation leading to stricture of the meatus or to extensive ostitis mastoidea, be called serious, as by these complications the injured person is not only rendered unfit for business for more than twenty days,* but very often has his hearing permanently impaired.†

In the estimation of injuries of the tympanic cavity and those complicated fissures of the temporal bone in which the pyramid, the walls of the tympanic cavity, and of the external meatus, and the base of the skull come within the range of the lesion, the time of the examination is of chief importance. Within the first few days after its occurrence a definite opinion on the nature of an injury can only be given when the latter is combined with such serious symptoms of a simultaneous lesion of the brain that an unfavourable termination may be foreseen. When, on the other hand, no symptoms of immediate danger are present, a definite prognosis should be postponed till such time as the termination and result of the lesion can be finally determined. We have seen, on the one hand, apparently slight injuries of the temporal bone lead to permanent disturbances and even to a fatal termination ; and, on the other, severe fractures, with profuse bleeding from the ears and even with discharge of cerebro-spinal fluid, heal up. It has been sufficiently well proved that the period within which the results of such injuries—when they do not cause a fatal termination—run their course, so that the process may be regarded as concluded, is usually very long. In the majority of these cases the injury is represented as serious in so far as there remains a lengthened disturbance of function and a permanent weakness of hearing. Also those lesions which have as their result a salivary fistula in the

* Austrian Penal Law on crime, transgression, and trespass, 1852, § 152.

† The estimation of injuries of the membrana tympani has already been discussed.

auditory meatus or paralysis of the facial nerve, must be termed serious, on account of the permanent injury to health, even when they are not associated with any disturbance of hearing.

The estimation of injuries caused by chemical and thermic agents depends on the result of the ulceration in the auditory meatus, the extent of the destruction of the membrana tympani, the consecutive suppuration in the middle ear (caries and necrosis of the temporal bone), and the degree of the disturbance of hearing remaining. What has already been said about the estimation of injuries holds good here also.

Ear Disease and Life Assurance.

To the medico-legal aspects of injuries of the sound-conducting apparatus we will add some remarks on life assurance in the case of people with ear disease. Although this theme has already been discussed, there has, as yet, been no consensus of opinion as to what class of people with ear disease should be admitted without endangering the interests of the assurance company, and what class should be refused. The views, also, as to the conditional acceptance, that is the admittance to life assurance with increased premium in certain forms of ear affection, have not been clearly stated.

The following affections of the ear are to be regarded as of no importance by life-assurance companies, as they neither influence the length of life of the assurer nor contain the germ of a dangerous disease: 1. All malformations of the auricle and of the external meatus, including congenital atresia of the latter. 2. The various forms of inflammation of the auricle, furunculosis of the auditory meatus, the slighter forms of otitis externa diffusa, eczema limited to the auricle and the external meatus, and exostosis and contractions of the meatus when they are not associated with suppuration. 3. All affections of the middle ear, which run their course without suppuration or perforation of the membrana tympani, in which the degree of the disturbance of hearing and complication with an affection of the labyrinth are out of the question. 4. All disturbances of the hearing which can be traced to a localization of the affection in the labyrinth. 5. Those exhausted suppurations of the middle ear in which the perforation in the membrana tympani becomes closed by cicatrization, whether it has become adherent to the inner wall of the tympanic cavity or not.

All persons in whom examination proves the presence of the following affections of the organ of hearing, are to be unconditionally rejected: 1. Ulceration of the auricle and of the external meatus,

due to the breaking down of an epithelioma. 2. Lupous affections of the external ear, as experience shows that individuals affected with lupus do not live long. 3. Contraction and exostosis of the external meatus associated with suppuration. 4. Chronic purulent inflammation of the external meatus with exposure of its osseous walls. 5. Chronic suppuration of the middle ear with perforation of the membrana tympani, especially (*a*) with formation of granulations and polypi in the tympanic cavity; (*b*) with desquamative processes in the middle ear; (*c*) with symptoms of caries in the temporal bone; (*d*) with paresis or paralysis of the facial nerve; and (*e*) with formation of fistulæ on the mastoid process. 6. All affections of the ear associated with giddiness and unsteady gait, when these symptoms cannot be traced with certainty to an affection of the organ of hearing, and when the possibility of a cerebral affection cannot with certainty be excluded.

A conditional acceptance, *i.e.* with increased premium, may be permitted in the case of those in whom, in consequence of a former suppuration of the middle ear, a persistent perforation (dry) remains in the membrane, as in these cases the suppuration returns more easily than when the opening is closed by cicatrization. The acceptance of such cases is rendered more difficult by the co-existence of chronic naso-pharyngeal catarrh or chronic pulmonary catarrh.

Not to be absolutely rejected, but to be deferred until the affection be completely removed, are: 1. All acute and chronic eczemas and diffuse inflammation of the external meatus, which extend deep into the canal and contract it. 2. Those suppurations of the middle ear which have lasted only a few weeks or months and admit of the possibility of a cure. If it is a case of curable ear-discharge, favourable results may be foreseen after several weeks' rational treatment. Should the otorrhœa not cease after proper treatment, the case is to be rejected. Cases which have been deferred for a time must be examined by a specialist, and it must be proved that their ear affection has been cured for at least three months. 3. All syphilitic ear affections in the presence of further symptoms of general syphilis (exanthems, pharyngeal ulcers, glandular swellings), as well as with simultaneous giddiness and staggering gait. When, on the other hand, the deafness has existed for years since the syphilis and all symptoms of the general affection have disappeared, the life may be accepted without fear, when no other circumstances forbid it, such as the suspicion of a syphilitic affection of the brain.

From what has been said, it is seen that the medical adviser of an assurance company is justified in rejecting those cases in which examination by the aural speculum shows great changes in the

external meatus and on the membrana tympani (granulations, polypi, fistulæ, otorrhœa with perforation of the membrana tympani, and so on); that, on the other hand, in all cases of ear-disease in which the decision of the assurance company as to passing the life depends on a more subtle objective examination of the organ of hearing, the case must be decided by a specialist.

The Diseases of the Naso-pharynx and of the Nasal Cavity with Reference to the Diseases of the Middle Ear.

As is well known, the diseases of the naso-pharynx and of the nasal cavity are not only frequently the forerunners of affections of the middle ear, but also exert an important influence upon the course and results of these affections. Their knowledge and treatment appears the more important for the ear specialist, as in middle-ear disease, by the occurrence or continuation of a naso-pharyngeal affection, the ear disease is continued and the return to the normal prevented.

It is not our intention to give an extensive description of naso-pharyngeal affections in this book. The knowledge of the pathology of the nasal cavity and naso-pharynx has recently received such advances from the labours of eminent investigators that the special discussion, the pathology and treatment of these organs, is necessary for practical purposes. Zuckerkandl's excellent works on the pathology of nasal diesases,* have a thoroughly scientific basis, and we would earnestly recommend their study to all ear specialists. As we would refer for the pathology and treatment of naso-pharyngeal affections to the extensive works of B. Fränkel, G. Michel, Mackenzie, Felix Semon, Voltolini, Bosworth, Massei, Ruault, Réthi, Moldenhauer, and Craswel Baber; we will only shortly sketch here the catarrh of the nose and naso-pharynx, and the principal methods of examination and treatment of these regions.

Methods of Examination.

(i.) *Examination of the Nose.*

In the examination of the nasal mucous membrane many obstacles are met with on account of the complicated formation of the nasal cavity. The examination of the central and posterior portions of the nose is particularly difficult, especially when by congenital

* Zuckerkandl, *Normal und Pathologische Anatomie der Nasenhöhle und ihrer pneumatischen Anhänge*, Wien, 1882 and 1892; 2 vols.

abnormal curvatures of the septum narium, or by deformities of the turbinated bones, or by pathological changes in the nasal cavity, the space is so narrowed that only the anterior portion is visible, and posterior rhinoscopy is impossible, owing to the hindered introduction of the pharyngeal mirror.

The examination of the nasal cavities from in front (rhinoscopia anterior, Cohen), by which the changes on the external wall of the nose, especially on the turbinated bones, and in the nasal meatus as well as on the septum should be brought into view, is done by instrumentally widening the nostrils and using as intense a light as is possible. For simple dilatation of the orifice of the nose, bivalved specula are used, such as those dilators designed by Fränkel, Roth, Bosworth and Delstanche. But in case of need, an ordinary large ear-speculum, or Itard's speculum may be employed. To illuminate the nasal cavities and the naso-pharynx is used either reflected sunlight, Auer's glowlight, or a gas or petroleum flame, the effect of which may be increased by convex lenses, or by the glass globe filled with water as recommended by Störk. The newly constructed electric lighting apparatus is being extensively used, especially in England and France.

With sufficient illumination the anterior extremity of the inferior turbinated bone comes first into view, and under favourable circumstances the convex surface as also the inferior margin of this bone can be traced to its posterior extremity. By inclining the head forwards, the base of the nasal cavity and the inferior meatus of the nose are seen, while by an inclination of the head backwards, the posterior and central spongy bones, in many cases portions of the roof of the nose, may be seen. With severe swelling and tumefaction of the mucous membrane, through which the space between the turbinateds and septum is narrowed, by painting with a 5 per. cent. sol. of cocaine the swelling which hinders a deeper view is temporarily, but seldom completely, removed. While generally a small fissure remains between the septum narium and the spongy bones, through which only a small portion of the posterior wall of the pharynx can be seen, a large portion of the naso-pharynx is visible if the spongy bones are undeveloped and widely spreading, as is principally seen in ozæna. In such cases we are able to inspect, besides the posterior wall and the roof of the naso-pharynx, the region of the orifices of the Eustachian tubes, and to discover pathological changes in their neighbourhood when such exist. With proper illumination we can recognise the cartilaginous tube as a yellowish swelling, from the anterior end of which a triangular fold extends downwards, and from its posterior and lower end a

similar crested fold (Zaufal) stretches to the soft palate. Between those two folds the ostium tubæ appears as a narrow fissure. During phonation, and during the act of swallowing, the lip-fold projects like a wing into the pharynx, and the base of the orifice expands as the levator veli contracts.

To view the naso-pharynx through the nasal cavity under normal conditions, Zaufal has proposed the use of cylindrical tubes (nose-specula) 3·7 mm. in diameter and 10 to 12 cm. long. Their introduction is not difficult if the capacity of the nasal cavity is sufficient to allow the introduction of the tube as far as the back of the pharynx. Under favourable conditions it is possible to cauterize the posterior wall of the pharynx and in the region of the tube through the Zaufal speculum.

(ii.) *Examination of the Naso-pharynx.*

The examination of the pharynx is divided into two parts, viz., examination of the inferior portion (cavum pharyngo-orale) and examination of the superior portion (cavum pharyngo-nasale).*

The examination of the inferior portion of the pharynx is effected in the simplest manner by pressing down the tongue as far as possible by means of a well-constructed spatula, and by requesting the patient to pronounce the vowel *a*, or better still, the consonant *h* (pronounced in German like *ha* in harbour), by which the soft palate is lifted up. With favourable illumination, diseased changes on the soft palate, tonsils, and posterior wall of the pharynx may be easily brought into view by this means.

Inspection of the posterior pharyngeal wall, lying behind the cavity of the mouth, frequently gives information as to the condition of the mucous membrane of the superior pharynx from the changes which can be there observed, such as swelling, congestion, tumefaction, escape of mucus from above, adherent crusts and granulations. Often, however, without the slightest visible change in the posterior pharyngeal wall, far-advanced affections of the mucous membrane of the superior naso-pharynx may be found. The absence of changes on the posterior pharyngeal wall does not therefore, render the examination of the superior pharynx by the pharyngoscope unnecessary.

The examination of the naso-pharynx is more difficult. To Czermak and Semeleder is due the credit of having introduced into practice this important method of investigation. The examination is performed by means of a round or oval pharyngeal mirror (pharyngoscope) analogous to the laryngeal mirror, by which the

* In the examination of the naso-pharynx the inspection of the posterior portion of the nasal cavity is made at the same time (*Posterior Rhinoscopy*).

walls of the superior pharynx and the region of the posterior nares are illuminated, and become visible by reflection in the mirror. The size of the mirror as well as its inclination towards the handle depend on the capacity of the pharyngeal cavity. If it is roomy, especially if the soft palate is somewhat removed from the posterior pharyngeal wall, a large-sized mirror may be used, because more light is reflected by it into the superior pharynx and into the posterior portion of the nose, those parts being thus more fully illuminated. If the pharynx is narrow, however, especially in children, if the tonsils are greatly swollen and the posterior pharyngeal wall and the soft palate are tumefied, only small mirrors $1\frac{1}{2}$ cm. long and 1 cm. wide can be used, as by the employment of larger mirrors choking and vomiting are set up, owing to irritation of the pharyngeal mucous membrane, and prevent inspection of the superior pharynx. By painting the soft palate and pharyngeal mucous membrane with a 5 to 20 per cent. sol. of cocaine the reflex irritability is occasionally so diminished that pharyngoscopy is successful even in bad cases.

The relaxed condition of the soft palate requisite for the success of the examination is obtained, according to Czermak's direction, by pronouncing vowels with a strong nasal accent, or according to Löwenberg's, by breathing through the nose. The various instruments constructed to elevate and draw the soft palate forwards can rarely be used, and only in certain operations. To make room for the mirror, it is advisable to make the patient turn his head to the side as far as possible, by which means the opposite side of the pharynx is widened.

The appearance with the pharyngoscopic mirror appears more or less clear, varying with the size of the naso-pharynx and the kind of pathological changes. In roomy pharyngeal cavities, the posterior surface of the soft palate, the upper, posterior, and lateral walls of the pharynx, with the changes which occur here: swelling, tumefaction, muco-purulent masses, crusts, ulcers, granulations, adenoid vegetations, polypi, and other new growths will be clearly seen.

Under favourable circumstances, especially when the soft palate stays well forward or is held so with a palate retractor, by the pharyngoscopy it is not only possible to see the walls of the naso-pharynx, but also the opening of the tubes and the projection behind them, the posterior portion of the nasal cavity; the posterior edge of the septum, the choana, the posterior end of the turbinateds, and occasionally also the bulla ethmoidalis extending into the middle nasal fossa will be clearly seen in the pharyngoscopic picture.

The pathological changes at the orifices of the Eustachian tubes and in their neighbourhood are of special interest.

In the normal condition the ostium pharyngeum tubæ will be seen in the form of a rounded triangle, with its apex directed upwards, which is bounded behind by the cartilage of the tube strongly projecting in the form of a pale yellow or yellowish-red swelling.

During forced breathing and when sounding a note, the soft palate with the strongly projecting protuberance of the levator curves from below towards this triangle, and the folds, extending from the lip of the tube, move nearer to the middle line. In pathological conditions, the lips of the tube bounding the orifice often appear very much congested and tumefied; the mucous membrane of the ostium tubæ also is itself swollen in various degrees; in many cases circumscribed follicular swellings can be distinguished. In the ostium itself masses of mucus are frequently seen, sometimes also crusts, which project from the naso-pharynx far into the cartilaginous portion of the Eustachian tube. In addition, ulcerations in the neighbourhood of the tube and at its mouth, with stricture of the same and flattening of its lip by ulceration, shrivelling and atrophy of the cartilage, have been observed.

The inspection of the superior pharynx by means of the pharyngoscope requires in some cases to be completed by examination with the probe and with the finger. A rectangularly curved probe, the same as that used for the examination of the larynx, is employed. While the point of the probe is carefully directed by means of the pharyngoscope, it is possible to feel the separate portion of the naso-pharynx, and thus to obtain information as to the character and extent of adenoid vegetations and other new growths.

Digital examination is effected by feeling the wall of the naso-pharynx with the forefinger, introduced from the mouth behind the soft palate, by which means the amount of swelling, the capacity of the pharynx and the seat, size, formation and mobility of possible swellings, may be ascertained. The finger should be protected by a metal band, and the finger-nail cut closely and made blunt. This mode of examination is advisable not only in those cases in which, on account of the already mentioned difficulties, the employment of the pharyngoscope is impossible, but also in many cases in which examination with the mirror is practicable, because with the mirror alone the presence of irregularities, especially if the walls are much covered with mucus, cannot be made out with the same certainty as by feeling them with the finger.

The digital examination has also the advantage that it is always successful, while the rhinoscopy posterior is scarcely ever successful in children, and in adults often only after a long-continued trial.

Catarrh of the Nose and Naso-pharynx.

Acute naso-pharyngeal catarrh is characterized by a severe diffuse hyperæmia and swelling of the mucous membrane of the naso-pharynx, which is accompanied at the beginning by a serous, watery secretion, later by a transparent or yellowish, tenacious mucus. Primarily the disease is most frequently due to external atmospheric influence, to bacterial infection, or to the action of irritating substances upon the nasal mucous membrane. To the affections of the last form belongs what is known as hay fever, a peculiar kind of acute disease of the nasal mucous membrane, accompanied by nervous symptoms, which, according to the new view, is produced mechanically by the inhalation of the pollen of blossoming grasses. It is observed during the haying season, especially in nervous, weak, or specially disposed persons among the better classes. This affection, which is rare in Austria, but very frequent in England and America (Bosworth), begins almost always with the symptoms of an acute rhinitis, and is frequently accompanied by asthmatic attacks. A participation of the ear in the inflammatory process of the nasal mucous membrane appears to occur very rarely.

Acute purulent infiltration of the naso-pharyngeal mucous membrane (phlegmonous inflammation, erysipelas), with the formation of abscesses and a purulent secretion, occurs on the whole very rarely, and is observed especially with diphtheritic-scarlatina, variola, and syphilis (Moldenhauer). Yet more rare is the acute infectious phlegmon of the pharynx (Senator, *Berl. klin.* W., 1888), occurring probably from putrid infection, with a diffuse purulent infiltration of the peripharyngeal tissue, and the deeper layers of the mucous membrane, and may produce a fatal result by extending to other organs.

The course of acute naso-pharyngeal catarrh, which in children, and occasionally also in adults, is accompanied by fever, headache, hindered respiration and depression, is under favourable conditions such that the mucous secretion ceases and the mucous membrane returns to the normal after several days, sometimes, however, only after weeks or months. The regeneration of a genuine catarrh follows especially rapidly in healthy individuals under favourable external conditions, and in warm weather. Very frequently the beginning of the Eustachian tube is swollen, covered with mucous, from which a feeling of fulness and bubbling in the ear is produced upon blowing the nose. That sero-mucous and purulent middle-ear inflammation may follow naso-pharyngeal catarrh has already been mentioned.

Treatment.—Acute catarrhal swelling of the lining membrane of the naso-pharynx as a rule does not require any treatment, for under normal conditions it generally soon subsides. It is nevertheless advisable, even in acute catarrhs, to avoid all sources of injury by which the cure might be delayed. Such sources of harm are: rapid change of temperature, especially in winter; remaining in a close locality or in air impregnated with tobacco-smoke; the use of alcoholic drinks, etc. Abrupt changes of temperature must be specially avoided by those in whom, at every recurrence of the acute swelling in the naso-pharynx, the disease spreads to the mucous membrane of the Eustachian tube, and produces a feeling of pressure and numbness in the ear.

Of the remedies recommended for acute catarrhal swelling of the pituitary membrane we must mention: the inhalation of steam, especially in young children with great tumefaction and obstruction in the nasal cavity; the inhalation of the strongly irritating vapours of acetic acid, ammonia and carbolic acid; and the painting of the naso-pharyngeal mucous membrane with a 10 to 12 per cent. solution of cocaine, by which the beginning coryza is occasionally checked. The insufflation of morphia (grm. $\frac{1}{8}$ pro dosi) proves beneficial, as the irritation producing sneezing and frontal headache is thereby greatly decreased. Unna and Grossmann have seen remarkable results from the ichthyol spray (ichthyol 0·50, æth. sulph. spirit. vini āā. 50). Occasionally the application of cacao-butter or a zinc salve to the anterior portion of the nasal mucous membrane has a beneficial effect. Terrier recommends the following mixture used as snuff: Bismuth subnitr. cryst. 7·5, gummi arab. 2·0, morphia hydrochlor. 0·03.

Of all the remedies enumerated it may on the whole be said, that they frequently relieve the troublesome subjective symptoms, but that they rarely have any influence on the course of the catarrh. Profuse diaphoresis by the use of hot drinks and vapour-baths, by which in many cases the cold in the head is soon cured, has, however, a better effect.

If the inferior portion of the pharynx be also at the same time congested, tumefied and discharging exudation, the catarrhal phenomena are alleviated by slightly astringent gargles. Owing to external or constitutional influences, especially following frequent attacks, chronic naso-pharyngeal catarrh develops from the acute form, which lasts for months or years, either with an equal intensity or usually with frequent variations, and may even continue throughout the whole life. Chronic catarrh often disappears during the summer, to return regularly again in the autumn. Frequent transi-

tion into the chronic condition is observed, especially in naso-pharyngeal catarrh occurring during the acute infectious diseases, in scrofulous individuals, or in those with some dyscrasia, and in congestion of the cranial vessels owing to lung and heart diseases.

The anatomical changes in chronic catarrh consist in a parenchymatous swelling of the mucous membrane, which is produced by enlargement of the bloodvessels, serous infiltration, and the deposit of cellular elements in the connective-tissue groundwork This cellular infiltration produces hypertrophy and connective-tissue induration of the mucous membrane. The adenoid or cytogenic tissue which is partly diffuse and partly collected in masses in the stroma, and, according to Zuckerkandl, is also found over a large portion of the nasal mucous membrane, usually participated largely in the swelling. The prominence of the swollen follicles above the surface of the mucous membrane produces the appearance of the follicular granular inflammation.

The excessive swelling of the nasal mucous membrane, which so often varies in acute, as well as chronic catarrh, is explained by the cavernous tissue on the turbinated bones described by Kohlrausch. Sometimes their convex surfaces, sometimes only their lower edges, are swollen, and it is characteristic of this swelling that it rapidly changes from one nostril to the other, so that one side will appear at times more, at other times less, permeable to the air. Most marked and by no means rare is the swelling and stationary hypertrophy of the posterior end of the lower turbinateds, which reaches such a degree that it extends through the choanæ in the form of a tumour or polypus, and partially fills the upper pharyngeal cavity.

The appearance in the nasal cavities by anterior rhinoscopy is very different, according to the extent of the swelling and infiltration, and is often different on the two sides. The mucous membrane of a bright or dark red, occasionally of a pale gray colour, appears covered in places with mucus, pus, or crusts, and especially on the edges of the lower, more rarely on the middle turbinated, is so swollen and enlarged that through immediate contact with the septum and floor of the nose the lumen of the nose is impermeable for the current of air. Granulations upon the mucous membrane of the turbinateds, which rarely occurs and only in localized places, gives an uneven, glandular appearance.

The secretion on the nasal mucous membrane shows the most varied modifications of serous, mucous, purulent, and blennorrhœal (Störk). With a moderate amount of secretion it dries in the anterior part of the nose, forming crusts. The quantity of secretion is sometimes very small, and sometimes so large that it flows freely

through the nostrils. If the secretion comes from a suppuration in the adjoining cavities of the nose, it will discharge periodically, especially when the head is bent to the opposite side. In empyema of the maxillary or sphenoid cavities, the openings of which are in the upper portion of the nasal cavity, the discharge of pus occurs mostly when the head is bent forwards. In those quite frequent cases, in which the catarrh is localized in the posterior portion of the nasal cavity, and that portion of the naso-pharynx bordering on it (retro-nasal catarrh), the mucus which flows towards the lower part of the pharynx is discharged through the mouth. If the suppuration is localized in the recesses of the roof of the pharynx, the secretion dries into large crusts, the removal of which is often accompanied by retching and sometimes by vomiting.

Of the symptoms accompanying naso-pharyngeal catarrh, besides the hindrance to respiration, the feeling of obstruction in the nose, fulness and heaviness of the head, and frontal headache, there is a combination of symptoms which have been brought to notice by Hack and Herzog. They develop most frequently with engorgement of the cavernous tissue on the lower, more rarely on the middle turbinated, especially in sensitive individuals, and with hyperæsthesia of the nasal mucous membrane. They are, however, by no means as frequent as was supposed by Hack and his followers. To this class of reflex symptoms, which, according to John H. Mackenzie, have their source in the erectile tissue on the posterior half of the middle and lower turbinateds and septum, belong paroxysms of coughing and asthmatic attacks, spasmodic sneezing, migraine, infra-orbital and supra-orbital neuralgia, vasomotor rhinitis (Herzog), aprosexia nasalis (Guye), more rarely rheumatic pain of the muscles of the face and neck (Réthi). With obstructed permeability of the nose the character of the voice is often markedly changed.

Nasal polypi may also be the cause of this form of reflex symptoms (Voltolini, B. Fränkel), as well as swelling on the turbinateds. The connection of the reflex symptoms mentioned with the changes in the nasal mucous membrane is shown by the fact that frequently the destruction of the swelling on the turbinateds (with the galvanocautery) or the subsidence of the existing nasal affection removes the nervous condition.

The result of chronic nasal catarrh in healing is much less common than is generally supposed. Even when the catarrh disappears during the summer, healing is often only apparent. The most frequent results are: Persistent swelling and hypertrophy, with varying hypersecretion of the mucous membrane, and the for-

mation of polypi in the nose. Mucous or cellular polypi, and more rarely fibrous new growths, are met with springing from the middle turbinated, and less frequently from the region of the hiatus semilunaris. Polypi in the naso-pharynx are less common; on the other hand, hypertrophy and growth of the adenoid tissue occur as a result of chronic nasal catarrh, especially in children. On account of its practical importance, and the frequent connection with catarrh of the tube and tympanic cavity, it will be described later. The result in atrophy of the mucous membrane, with disappearance of the follicular elements, occurs, according to Moldenhauer, most frequently with chronic retro-nasal catarrh. Whether the accompanying disturbance of hearing is produced by a consecutive atrophy of the muscles of the tube has not been proved.

Ulceration on the nasal mucous membrane is most frequently seen with syphilis, more rarely with scrofula and after variola. The ulcus septi nasi perforans,* which is produced by gradual necrosis of the epithelium of the mucous membrane and the cartilage, is found only in the cartilaginous septum, and usually in the anterior portion, with sharp edges. The syphilitic ulcer, which extends on to the osseous septum, is characterized by its greatly infiltrated edges, and its sagittal direction. When the ulceration is situated in the middle and posterior portions of the nasal cavities the ulcer penetrates into the deeper layers of the mucous membrane, and when localized healing is accompanied by the formation of scars or an ozæna syphilitica develops. Should the destruction extend to the osseous walls of the nasal cavity, a portion of the roof of the nose, the nasal septum, the turbinateds and the hard palate may be exfoliated through necrosis, and a communication be formed between the two sides of the nose, and between these and the mouth. Réthi also saw with tuberculosis, exfoliation of a portion of the floor of the nose, with a casting off of large pieces of the palatine processes, and perforation of the external wall of the lower meatus.

Whether what is known as ozæna simplex (atrophic rhinitis) with atrophy of all the tissues of the nasal mucous membrane and the osseous walls of the nose, is to be considered a result of a chronic catarrh or as a peculiar form of disease of the nasal mucous membrane (Moldenhauer) which may develop without a previously existing catarrh, must be decided by a continued clinical observation. Neither has it been conclusively proved whether the inherited width of the nasal cavities (Zaufal, Rosenfeld) or a hypertrophy of the

* Comp. Zuckerkandl, *l.c.*, p. 153, Taf. 17, Fig. 1, and Hajek, 'Perforating Ulcer of the Septum' (*Arch. f. patholog. Anatomie*, Bd. 128).

middle turbinated (Krause, Berliner) should be considered as the cause of the ozæna. Grünwald has lately brought forward again the view held by Michel, that ozæna as well as dry pharyngeal catarrh is principally produced by disease of the neighbouring cavities. That ozæna occurs most frequently with the scrofular dyscrasia, in anæmic and ill-fed individuals, mostly at the time of puberty and more often in females, is proved by numerous clinical observations. The combination of ozæna with ear diseases is much more rare than would be supposed from the extension of the process towards the opening of the tube. Where the ear is also affected, sclerosis of the mucous membrane of the middle ear is most frequent, more rarely ostitis purulenta.

Löwenberg first found a micro-organism (capsulated coccus) in the secretion of ozæna, which probably produces the septic decomposition and the penetrating fetor of the secretion. Rohrer found a bacillus in the secretion of ozæna which showed decomposing characteristics in culture experiments.* Ozæna simplex never goes on to the formation of ulcers on the mucous membrane (Hartmann, Zaufal) and to carious affection of the bony framework of the nose, which distinguishes it from the ozæna occurring in syphilitic naso-pharyngeal affections.

The picture of ozæna by rhinoscopy anterior is so characteristic that the observation of a few cases is sufficient to make a diagnosis without any trouble. If the crusts and secretion which are adherent to the mucous membrane and often require to be loosened with a sound are removed by syringing, the abnormal width of the nasal cavities, the atrophic, shrunken turbinateds and the paler grayish-red mucous membrane without tumidity become at once apparent. The width of the nasal cavities allows a view not only of the walls of the nose, and often of the openings of the sphenoidal cavities and the hiatus semilunaris, but also of a greater part of the posterior wall of the pharynx, and the openings of the tubes, and the previously described movement of the projection of the tube during phonation. In most cases a dry pharyngitis with a varnish-like cover of secretion is present.

Treatment.—Chronic naso-pharyngeal catarrh, especially after several years' duration of the disease, and in scrofulous, anæmic individuals who have become reduced in their nutrition, is very tedious. Although chronic catarrh heals in some cases after long-continued treatment, yet in most cases only an improvement is

* Comp. Hajek, 'The Bacteria of Acute and Chronic Coryza, as well as Ozæna, etc.' (*Berl. Klin. Wochenschr.*, 1888).

obtained by local means, and many cases remain unhealed even after the proper treatment.

The effect of medicamentous substances upon the diseased mucous membrane varies very much individually, and cannot be foretold. It is therefore often necessary to try a number of medicines in a given case, until the one is found which is specially suited. The medicine is used either dissolved, or in the form of a powder.

The medicated solutions are applied to the membrane either by instillation and syringing them into the nose, or by the nasal douche, or as a spray.

By means of the nasal douche ('Weber's douche'), the fluid is conducted into one of the nasal orifices from an irrigator or other vessel by means of an india-rubber tube, furnished with an olive-shaped nozzle, and which acts as a syphon. By pouring fluid upon the upper surface of the soft palate, closure of the inferior pharynx will take place by reflex action, and thus the fluid, the escape of which downwards is prevented, will flow off through the other nasal orifice.

By means of the nasal douche, the medicated solution will be applied to the mucous membrane of the naso-pharynx on all sides, and the masses of mucus and crusts lying in the recesses of the nose will be washed out. In spite of the great advantages of this method, it has certain disadvantages which by inattention to the cautions to be described may manifest themselves in a very serious manner. Of the serious accidents which may occur with Weber's nasal douche are specially to be mentioned, the penetration of the fluid into the frontal cavity with the following frontal headache, and the entrance of the fluid through the tube into the tympanic cavity, after which, as has already been described, the symptoms of a severe middle-ear suppuration with perforation of the membrana tympani may develop (Roosa, Knapp).

In using the nasal douche the following precautions are to be observed: 1. The vessel must not be placed too high, as the fluid should enter the nose under slight pressure. 2. The head must not be tilted too far forward or too far backward. While using the douche the patient must breathe regularly through the mouth; it is even better to continually sing the vowel *a* (Löwenberg). 3. When the nasal cavities are of different widths, the fluid should be allowed to flow through the narrow side. 4. The fluid must always be luke-warm and concentrated, irritating solutions should never be used. 5. The use of Weber's douche should only be allowed to the patient for self treatment, when after using it several times it is shown that he understands the manipulation thoroughly. Where even with

slight pressure the fluid penetrates into the tympanic cavity, the use of the douche must be discontinued.

The nasal douche of E. Pins consists of a glass bottle with a double perforated rubber stopper, into which are inserted two glass tubes. The longer tube, which leads to the bottom of the bottle, has an olive tip with a large perforation on its end; the shorter tube is provided with a mouthpiece. If one blows, with full cheeks, through the latter into the bottle, the fluid will be forced through one nostril into the naso-pharynx, and flow out through the other nostril. The propelling force is here the increased expiratory pressure, by which means the soft palate is tightly stretched, and the upper pharyngeal space completely shut off. At the same time the ostium pharyng. tubæ is narrowed by the tightly-stretched palate, and the entrance of fluid into the middle ear is hindered thereby.

Of the medicated solutions used with the nasal douche, the following have proved most efficient: 1. Solutions of tannin, of which the amount that can be held on the point of a knife is dissolved in 60 to 100 grms. of luke-warm water. The action of this drug is increased, especially with a purulent discharge from the nasal mucous membrane, by the addition of quinia sulph. (tannin 3·0, quinia sulph. 0·1), or of acid. salicyl. (tannin 3·0, acid. salicyl. 0·3). 2. Argilla acetica (acetate of aluminium) proves useful at times in a 10 per cent. solution where a whole series of drugs had previously been used without result. 3. Aluminium acetico-tartaricum recommended by Schäffer and Lange, of which a teaspoonful of a 25 per cent. to 50 per cent. solution is used in half to one quart of water, as a nasal douche. Alum solutions are to be avoided as after their use permanent loss of smell has been observed (Wendt). 4. A 3 to 4 per cent. solution of boric acid. 5. A 1 per cent. solution of common salt or diluted Ischler or Kreuznacher spring (salt) water, of special use when there is a scrofulous diathesis. 6. A solution of the powder recommended by Störk: Sod. salicyl., sod. bicarbon., sod. chlorat. āā. 20·0 (a teaspoonful to a quart of water). 7. Oleum terebinthinæ (5 to 15 drops in a quart of water), with a blennorrhœal secretion of the naso-pharyngeal mucous membrane. 8. Mineral water containing sulphuric acid or a solution of a teaspoonful of pulv. sulfuros. pouillet (calcar. sulph., pot. sulph., sod. sulph., sod. bicarb., acid. tartaric., pulv. gummi arab. āā. 20·0), in 1 to 2 quarts of water. The tartaric acid can be replaced by benzoic or salicylic acid. 9. Solution of ichthyol, which, according to Grossmann, is of good service used in a 5 to 10 per cent. solution, as a spray, or painted on the surface in a 25 to 30 per cent. solution.

Although healing is occasionally brought about by the continued use of the nasal douche, yet it is frequently quite ineffective, and

experience shows that many cases of naso-pharyngeal catarrh will not heal until the nasal douche is entirely stopped. Guye has proved that after the long-continued use of the nasal douche, chronic, stealthy middle-ear catarrh can develop. This is confirmed by the observations of Löwenberg, who saw in unilateral affections, after using the frequent nasal douches in the baths of Cauteret, that the formerly normal ear was affected with sclerosis.

The injection of medicated solutions from the mouth by means of a curved tube inserted behind the palate (posterior nasal syringe) is to be avoided, for by this means the fluid will easily enter the middle ear and produce severe inflammatory symptoms.

Where it is wished to apply the medicated solution to the diseased mucous membrane without using the strong side-pressure, it is sufficient to pour the fluid into the nose. This is most easily done with a boat-shaped glass vessel (Fig. 287), from which about 30 grms. of the solution are allowed to flow into the nostrils while the head is bent backward. In order to prevent the fluid from running into the lower pharynx, the patient is instructed while pouring the fluid to breathe strongly through the mouth, or to sing *a*, and at the moment when the fluid is felt in the pharynx to bend the head quickly forwards. The fluid, which will go into the other side of the nose owing to the closure of the palate, will flow out through both sides. In order to prevent the fluid from being forced into the middle ear after it is poured in, the patient should not be allowed to blow his nose for 15 minutes after using the medicine.

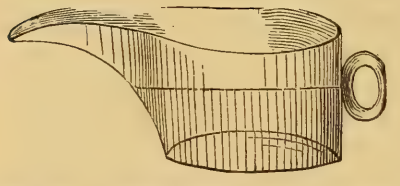

FIG. 287.—GLASS VESSEL USED TO POUR FLUID INTO THE NOSE ($\frac{1}{3}$ THE REAL SIZE).

Pouring fluid medicaments into the nose is indicated with secreting, swollen conditions of the nasal cavities, with crusts in the naso-pharynx, in ozæna to loosen the crusts before using the nasal douche, lastly with retro-nasal catarrh to soften and loosen adherent lumps of mucus and crusts from the posterior surface of the soft palate. With chronic cases of the latter disease, its daily use is indispensable, as only through this means can the annoying retching and efforts to vomit be relieved.

Of the many varieties of atomizers recommended for the treatment of naso-pharygeal affections, that by v. Tröltsch has found general use. The anterior end of the atomizer is introduced through the nose into the naso-pharynx. By this means the effect of the medicament is localized to the upper part of the pharynx and the region of the tube, and more concentrated solutions can be used than with the Weber douche.

If after treatment for several weeks by the above solutions the condition of the lining membrane of the naso-pharynx does not materially improve, the desired result will frequently be effected by touching it thoroughly with a concentrated solution of nitrate of silver (1·0 to 10·0). The cauterization may be performed in various ways, either by applying the solution immediately to the diseased parts by means of a brush or a small sponge, or two balls of cotton-wool the size of a hazel-nut, saturated with a concentrated solution of nitrate of silver, are pushed by means of the forceps through the dilated nasal orifices towards the centre of the nasal cavity, and the nose is afterwards closed with dry wadding. Then, the head being inclined backwards, the fluid is squeezed out of the balls of cotton-wool by compressing the nose with the forefinger and thumb, and in this manner a great portion of the lining membrane of the naso-pharynx is cauterized. After the removal of the cotton-wool by means of the forceps it is advisable to wash the neighbourhood of the nasal orifices with a weak solution of iodide of potassium, to prevent black spots.

Cauterization of the lining membrane of the naso-pharynx, performed in this manner, as a rule immediately causes a violent burning sensation with increased discharge; both however disappear in a short time. It is only rarely necessary to neutralize the effect of the nitrate of silver solution by pouring in warm water or a warm, weak saline solution when the reaction is very severe. A material improvement is frequently noticeable after even a few days, as the patient feels relieved and the breathing through the nose is less impeded. The number of cauterizations, which have to be performed two or three times per week, varies from 3 to 10.

Extensive cauterization of the naso-pharynx is effected by using either a brush provided with a suitably curved handle, or small sponges fastened to a whalebone staff, which are dipped into a concentrated solution of nitrate of silver. These are pushed forward behind the soft palate, are turned towards the superior pharynx, and by slightly shifting them from right to left its walls are painted. The sensitiveness of the pharynx can be diminished before touching with a cocaine spray.

To subjectively alleviate the unpleasant feeling of dryness in the upper part of the pharynx, which occurs with an atrophic mucous membrane, painting with a solution of iodine, potassium iodide, and glycerine (0·5 to 1·0 in 25, Moldenhauer), or borate of glycerine is used with advantage.

The insufflation of powdered medicines is either done through the nose or from the pharynx, during which *a* should be sounded

(Löwenberg) in order to prevent the powder from entering the larynx. In the first case the powder remains more in the anterior part of the nose, in the latter the medicament is applied directly to the mucous membrane of the naso-pharynx and the posterior part of the nose.

The medicines most frequently used in the form of a powder are: alum, finely powdered, or mixed with gum arabic or sugar of milk, tannin, oxide of zinc, calomel, argent. nitrate, boric acid, the recently recommended aristol and europhen, derivatives of iodine, which, besides their antiseptic properties, also act as a styptic. According to Bresgen, who prefers the argent. nitrate in the powdered form for chronic nasal catarrh, one should begin with a mixture of 0·05 arg. nitr., 10·0 amylum, and increase up to 1 in 10, only applying it to one side of the nose at once. Besides this, Bresgen recommends as being specially effective, sozoiodol-zinc in a mixture of 1 to 2 parts to 10 of iodol.

To insufflate the powder, one should use a suitable powder-blower, or a rubber cannula which has a balloon attached and can be introduced deeply into the nose. With obstructions in the nose, the powder should be blown into the upper part of the pharynx with a bent hard-rubber tube introduced behind the palate through the mouth.

When there is a large amount of hypertrophy of the mucous membrane of the turbinateds, simple astringents are not sufficient, and the hypertrophied parts must be systematically cauterized. The solid caustics most frequently used are: Argentic nitrate, chromic acid, zinc chloride (in concentrated aqueous solution applied in drops), and glacial acetic acid (Ehrmann). The simplest caustic application for the nares is a sound with a short groove on the side, in which the solid nitrate of silver or a few crystals of chromic acid can be melted. The crystals of glacial acetic acid are applied best, according to Réthi, with a flattened silver sound, the end of which is hollowed out like an ear-spoon. For chromic acid the small spatula ridged along the side is suitable (Krause), upon which the acid crystals are melted with an alcohol lamp. Through linear cauterization of the turbinateds, with the medicines named, the troublesome nasal swelling often disappears entirely, yet old hypertrophies are often so obstinate that the galvano-cautery must be used.

In cases of great tumefaction of the lining membrane of the naso-pharynx, in order to cause subsidence of the coincident swelling of the mucous membrane of the Eustachian tubes, I frequently perform circumscribed cauterizations near the orifices of the tubes. I use for this purpose a wide, slightly curved vulcanite catheter, in

which a long movable wire is inserted, the point of which has received a coating of nitrate of silver in the form of a ball. The small ball, which during introduction into the nose is hidden in the catheter, is pushed out when the point of the catheter has arrived at the region of the ostium tubæ, the neighbourhood of which is cauterized by slightly shifting the catheter backwards, forwards, upwards, and downwards. Before the instrument is taken out the point of the wire must again be withdrawn into the catheter.

Fig. 288.

The treatment of the almost incurable ozæna has for its object the removal of the stagnating secretion as frequently as possible, and thereby obviating the disagreeable fetor. The antiseptic cleansing of the nose with Weber's nasal douche is not sufficient in all cases to thoroughly remove the masses of mucus and crusts, it being frequently necessary to syringe them out with a large syringe provided with a flexible rubber tube rounded on the end, and fenestrated on the side. The rubber tube is deeply inserted into the nose, and through turning the syringe the naso-pharynx is washed out on all sides, the crusts loosened and removed without producing the pressure which is done by Weber's nasal douche. The nose must be washed out daily and often for years, sometimes even it must be continued through the whole of life. As a fluid for washing out the nose, weak salt solutions are sometimes used, sometimes the antiseptic solutions already described for the nasal douche. Löwenberg recommends the use of a weak sublimate solution (1 in 10,000), followed by the insufflation of boric acid. E. J. Moore irrigates daily with 1 to 2 quarts of sulphur water, later adding sea-salt or pot. chlorate, following with an irrigation of disinfecting solution, which is varied occasionally, and lastly insufflating tannin or citric acid in the powdered form (*Revue mens.*

de Laryngologie, 1885). Voltolini syringes daily with tar-water. Ruault cleanses the nose, disinfects with naphthol-camphor (1 in 2), and then sprays with vaseline and naphthol-camphor (0·01 in 100). Löwenstein recommends europhen; Bresgen the sozoiodol-zinc in the above-described mixture without syringing, having previously wiped out the crusts. Iodol, boric acid, calomel, etc., are also recommended. Jurasz gave up the dry treatment as the formation of crusts is made worse by the powder; cauterizing the atrophic mucous membrane has proved useless.

In many cases the secretion will be decreased and the bad character of the secretion removed by the patient himself painting the nasal mucous membrane with a bichloride solution (0·1 in 50) or with Argill. acet. Burowi. According to Gottstein the only means of removing the fetor in atrophic rhinitis is to tampon the nasal cavities with little pledgets of cotton, which are left in the nose for 2 to 3 hours, after previously washing it out. The vibration massage proposed by M. Braun (*Berl. Congr.*, 1890) and carried out by Laker, which is done with a long, stout sound wrapped with cotton and dipped in a medicated solution, only produces a better condition of the mucous membrane and a visible improvement in a few cases.

A method of treatment for hypertrophy of the nasal mucous membrane—the results of which are much exaggerated—is the use of the galvano-cautery (Voltolini, Hartmann, Löwenberg, and Michel). The platinum cautery (Fig. 288) is recommended (Löwenberg), with which the hypertrophied mucous membrane of the lower turbinated can be cauterized along its lower external surface in a line from behind forwards. By using this, cauterizing the septum with the bridge-like adhesions between the turbinateds and septum which it produces are prevented. Before cauterizing the nasal mucous membrane it is anasthetized by painting with a 10 to 20 per cent. solution of cocaine, or according to Rosenberg with a 30 to 50 per cent. alcoholic solution of menthol.

By means of the galvano-cautery treatment in some cases it is possible to rapidly reduce the swelling of the mucous membrane of the turbinateds, and occasionally after a few cauterizations a marked subjective improvement in breathing and cessation of the headache results. After cauterizing the turbinateds a decrease, rarely a complete cessation, of the subjective noises in the ear is observed, from which it can be concluded that there are connections between the turbinateds and the ear which have not yet been discovered. With the involution of the nasal swelling in some cases the reflex asthma (Woakes) and other reflex symptoms which come from the nasal

mucous membrane disappear, while frequently, in spite of the destruction of the swollen tissues, the asthma remains. A peculiar indication for the galvano-caustic treatment of the nose in asthma exists in those cases in which no other more direct cause cannot be found, and farther when it is possible to produce a spontaneous attack by the pressure of the sound on the turbinated bones or to stop the attack by cocainizing the particular spot. The galvano-cautery should only be used on the inferior turbinated; cauterization of the middle and superior turbinated bones is to be avoided. The galvano-caustic treatment of the nose is without result in many cases, and it must be remarked here that it has been done more frequently than necessary during the last few years. Although experience proves that the nasal mucous membrane will stand many interferences without trouble, yet frequent observations have shown that after cauterization with the galvano-cautery as well as by other means (nitr. argent., chromic acid), especially of the middle turbinated, severe accidents, dizziness, vomiting, fainting, amaurosis (Rosenberg), hyperæmia and venous pulsation of the optic papilla (Ziem), neuroses (Réthi), and even in some cases death from meningitis, have resulted. Swelling and the growth of ranulations in the naso-pharynx are best treated from the pharynx by means of a properly bent galvano-cautery burner, which is guided by the pharyngeal mirror.

Polypi in the nose are usually found in the middle, more rarely in the anterior portion, as one or more roundish yellow or grayish-red tumours, which hinder the respiration on that side when they reach a larger size. They usually arise, as already described, on the turbinateds, and only rarely from the septum or the region of the hiatus semilunaris.* That they may grow into the nose from the ethmoid cells (Woakes), from the sinus ethmoidalis, from the processus spheno-ethmoidalis, and the other cavities adjoining the nose, has been proved by the instructive and interesting investigations of Zuckerkandl.† The examination with the sound will show the size, movability, and attachment of the tumour, which is often visible with the naked eye. The examination with the sound is the more important, as sometimes the deformed and hypertrophic turbinateds may simulate a polypi from examination with the mirror. The diagnosis of retro-nasal polypi requires a careful examination with the pharyngeal mirror, and should be completed with the assistance of the sound and digital examination.

The former method of extracting polypi with a dressing forceps

* Craswel Baber, *Reflex Nasal Cough*, London, 1886.

† Zuckerkandl, *Normale und path. Anatomie der Nasenhöhle*, Bd. II., S. 81.

has been supplanted by the use of the polypus snare (v. Tröltsch, Bruns). Of the numerous modifications, those by Störk, Hartmann, Zaufal, Blake, and Ch. Delstanche have proved the best. The snare, provided with thin piano wire, is introduced into the nose, after dilating with Bosworth's speculum, the wire being shoved over the polypus as far as its root, is drawn back and the polypus cut off. If the polypus is not cut through, and slight traction is not sufficient to remove it, the snare is twisted several times, the wire cut through at the back of the instrument, and the remaining wire left as a ligature until the polypus disintegrates and is cast off. Remainder of polypi in the lower part of the nose are most quickly destroyed with the galvano-cautery (Löwenberg). When not having a galvano-cautery apparatus they can be cauterized with ferri muriat. or chromic acid. Larger polypi which extend from the posterior part of the turbinateds through the choanæ into the upper part of the pharynx (Craswel Baber) are removed by bent snares introduced behind the soft palate (Störk).

To snare off the polypoid degenerated posterior ends of the turbinateds Réthi invented a galvano-cautery snare, which can be introduced through the anterior nares. The loop is drawn in with a screw under the guidance of the rhinoscope.

Rare new-growths of the nose and naso-pharynx, as papilloma, enchondroma, sarcoma, as well as the fibrous and sarcomatous growths, springing from the sphenoid, are only of interest to the ear-specialist in so far that they frequently close the opening of the tube and produce signs of tubal obstruction. The malignant tumours and those springing from the bone are incurable; on the other hand, benign tumours may either be removed by operation or destroyed by electrolysis. By the latter method De Rossi secured complete healing in two complicated cases of nasal polypi.

The Adenoid Vegetations of the Pharynx and their Treatment.

The adenoid tissue of the naso-pharyngeal mucous membrane which forms the pharyngeal tonsil (Luschka*), situated in the middle line of the upper pharynx, is not only hypertrophied by chronic inflammation, but forms such large vegetations through the excessive formation of new adenoid tissue that the choanæ are closed and the respiration through the nasal cavity hindered. In some cases a broad-based adenoid tumour grows from the upper wall of the pharynx, which not only fills the naso-pharyngeal cavity, but extends into the lower part of the pharynx and presses the palate forwards.

* *Die Hypertrophie der Rachentonsillen, etc.* A monograph. Berlin, 1886.

Trautmann proved, from anatomical and clinical observation, that the anterior part of the pharyngeal tonsil first becomes hyperplastic, while the posterior portion is affected later. On the protuberances behind the Eustachian tube and its vicinity as well as on the side walls of the pharynx Trautmann never found the growths, while Moldenhauer says that he has seen hyperplasias of the adenoid tissue on the side wall of the pharynx.

The bursa of the pharyngeal tonsil (recessus pharyngeus medius), the anatomical relations of which have been studied by Mayer and others, may be, as Thornwaldt stated, the starting-point of pathological changes—hypersecretion, formation of bridges, and cystoid degeneration—yet the primary and isolated commencement of pathological changes in the recess. phar. med. is in nowise proved.

The growth of adenoid vegetations in the naso-pharynx, which occurs especially in children, is most frequent in the northern rough climates. The growths frequently disappear spontaneously after puberty according to my observation. One rarely sees them after 25 years of age.* They are frequently complicated with great swelling of the tube and sero-mucous catarrh, more rarely with suppuration (Barth) which cannot be cured until the adenoid vegetations are completely removed. Adenoid growths in the naso-pharynx either produce laboured breathing through the nose or stop it entirely by covering the choanæ. For this reason the respiration can only be performed through the open mouth, which gives the affected individual an idiotic expression (W. Meyer). The aprosexia nasalis described by Guye is especially frequent in children affected with adenoid vegetations.

The diagnosis of adenoid vegetations can only be made with certainty by digital examination, as this alone gives absolute certainty as to their localization, size, extent, form and resistance. The diagnosis will be supported by pharyngoscopy, by the presence of flat granulations on the posterior wall of the pharynx buccalis, by the great distance of the palate from the posterior pharyngeal wall (Hedinger), and by the peculiar idiotic expression produced by breathing through the mouth. In rare cases, according to Moldenhauer, considerable restriction of the development of the upper jaw occurs, which is manifested by a peculiar, sidewise contraction of the alveolar process and limited development of the canine teeth. Deformation of the thorax, observed by Löwenberg, occurs very rarely. Hypertrophy of the tonsils frequently occurs (19 per cent.) with hyperplastic growth of the naso-pharyngeal tonsil (M. Schäffer).

The treatment of adenoid vegetations in the naso-pharynx is

* H. Cuvillier, *Des Végétations adénoides chez l'adulte*, Paris, 1891.

entirely operative, and by the valuable work of W. Meyer in Copenhagen great progress has been made in the treatment of naso-pharyngeal diseases, and the ear affections depending thereon.

The operative procedures of W. Meyer have received many modifications in the course of years, and I will here describe shortly the most important methods of operation for adenoid vegetations.

I. *Operations with Ring-shaped Knives.* — (*a*) The ring-knife of W. Meyer (Fig. 289), the sharp cutting surface of which is formed by the inner edge of a ring 1 cm. wide. Its length is about 21 cm., and the instrument being introduced perpendicularly between the septum and turbinateds, is shoved to the back part of the pharynx, and then so turned that the ring is horizontal. As the knife is now pressed upon the excrescences with the index-finger of the left hand, which is introduced through the mouth behind the

Fig. 289.

palate, the instrument is pulled out with the right hand, and the vegetations which entered the ring removed. The repetition of the operation depends upon the number and extent of the growths, and it must be continued until digital examination shows no more vegetations which can be reached by the instrument. The narrowness of the nasal cavity limits the movement of the instrument, for which reason only a portion of the growths can be removed. Lange's curette, cutting on the side, cannot be recommended, on account of the danger of injuring the projection behind the tube.

(*b*) The fenestrated pear-shaped knife by Gottstein (Fig. 290), has a triangular form, the base of which is above and the point below, the anterior end being at nearly right angles with the horizontal handle. The sides of the triangle are rounded off both internally and externally, but the inner edge of the triangle is sharpened as a knife. The height of the opening is about 2 cm., the breadth at the base 1 to 1½ cm. The operation is done as follows: the instrument is introduced behind the soft palate into the upper part of the pharynx, and pressed against the adenoid vegetations by lowering the handle of the instrument as much as possible. By a strong backward movement of the instrument, from the upper to the posterior wall of the pharynx, a greater part of the adenoid vegetations are cut off, and, after repeating the operation several times, all diseased tissue can be removed from the upper wall of the pharynx. By performing the operation rapidly the cut-off vegetations may be removed with the knife. I have used for several years, with advantage, a modified Gottstein's knife, on which the anterior surface of the upper portion is bent saddle-shaped. By pressing the instrument on the roof of the pharynx, the spine projecting in the median line (a continuation of the nasal septum) lies

Fig. 290.

in the groove of the instrument, so that the vegetations lying to the side of the spine can be completely removed.

II. *Sharp Spoons to Scrape and Scratch off Adenoid Vegetations.*—(*a*) Justi's sharp spoon is a small oval spoon with a short handle, fastened by a ring to the index-finger, and introduced behind the soft palate, with which the adenoid vegetations can be scraped away.

(*b*) The sharp finger of Capart and Bezold, in which the spoon is so modified that it forms a simple extension of the finger-nail. The upper portion, projecting beyond the finger, is about the width of the finger-nail and has a sharp edge.

(*c*) Trautmann's sharp spoon is larger, round, and deeply concave, and is fastened to an inflexible handle bent at an obtuse angle (150°) so that the concavity is directed upwards. With this Trautmann removes the adenoid vegetations from the upper part of the pharynx in a few short sittings.

Scraping the adenoid vegetations away with the finger-nail, which is recommended by a good many, can only be done when the growths are soft and flat; with large and hard vegetations this procedure is insufficient.

III. *Forcep-shaped Instruments.*—(*a*) The ridged and fenestrated forceps for removing adenoid vegetations, first recommended by Löwenberg and Catty, have been modified in many particulars by Schech, Delstanche, Mackenzie, and others.

Those which have proved the most efficient are the sharpened gouge-shaped forceps, by Michel and Löwenberg; the spoon-shaped forceps, by Schech; the choana forceps, cutting from in front backward, by Schütz; the adenotome à coulisse, by Ch. Delstanche; and the spoon-shaped cutting forceps, by Chatellier and Menière. The latter has the disadvantage that occasionally the posterior part of the vomer, or the projecting spine on the roof of the pharynx, is fastened with it. The properly curved forceps is introduced, closed, behind the soft palate to the upper part of the pharynx, then opened, and by strongly pressing together, the adenoid vegetations, which enter between the branches, are squeezed or cut off.

IV. *Snares.*—These are now rarely used for the removal of adenoid growths The most serviceable are:

(*a*) The steel-wire guillotine of Störk, in which a wire lies in a fenestrated oval steel handle. By pressing the handle on the upper wall of the pharynx, and pulling back the wire, the growths which entered the opening, or larger tumours hanging from the roof of the pharynx, are removed.

(*b*) Hartmann's snare, with a tube bent at right angles. The operation is carried out from the pharynx buccalis, by snaring off separate growths under control of the pharyngoscope, or, where this is not possible, under control of the finger.

(*c*) The removal of adenoid vegetations with a snare introduced through the nose, first proposed by Bezold, is only rarely done. Most suitable for this are Blake's snare with a long cannula, and the instrument by Delstanche, called 'Etrangleur droit,' in which a watch-spring, covered by a cannula, is introduced in the naso-pharynx unwound, and by pulling in removes the enclosed growths. The removal of vegetations with the galvano-cautery snare has been discontinued. Of the disadvantages of this method, Michel

places first the reactive inflammation due to the radiation of heat in the region of the operation and the transmission of a reactive inflammation from the naso-pharynx to the middle ear.

The operative removal of adenoid vegetations is best done without narcosis, provided that one has in hand a well-bred, sensible child who will not offer any disturbing resistance to the operation. With disorderly children it is better to do the operation under light chloroform narcosis or under æthyl bromide narcosis, which is quickly over. When using the ring-knife the patient must be sitting for the operation, and care must be taken that the blood does not flow towards the larynx and produce suffocation. When Chatellier's forceps are used, which must be introduced several times in order to remove all at one sitting, the patient should lie on one side, by which the danger of suffocation is avoided. After the operation, the naso-pharynx is cleansed from blood by a sterilized sponge, and lastly an insufflation of boric acid made through the nose. Of the bad accidents after the operation, the consecutive otitis media acuta is especially to be mentioned, which occurs mostly after scratching them out with a sharp spoon.

Cauterizing the adenoid vegetations, which was formerly done, is now dispensed with, since its slight effectiveness has been proved.

As regards the treatment of the affections of the cavities adjoining the nose, Hartmann has proved that by compression of the air in the nose fluids accumulated in the adjoining cavities can be removed, and that not only in acute but also in chronic catarrh the symptoms (frontal headache, heaviness and numbness in the head and sensation of weight in the upper jaw) will be alleviated or completely removed after repeated Politzerization. In several cases treated by me, the continued frontal headache was alleviated by passing a smooth, elastic rubber tube rounded at the end (p. 411, Fig. 228) in a vertical direction through the nostril towards the frontal cavity, and blowing air through it several times with the balloon. Sounding the frontal cavity, which communicates with the nose through a narrow canal which is often tortuous, is usually very difficult. Jurasz* succeeded in sounding the cavity in half of his cases.

With a collection of secretion in the antrum of Highmore, which can be diagnosed by the transmission of an electric light from the mouth (Heryng, Vohsen, Davidsohn), radical healing can only be brought about by opening the cavity from the nose, from the canine fossa, or by the removal of a tooth. Empyema of the frontal sinus

* *Ueber die Sondirung der Nebenhöhlen der Nase*, *M. f. O.*, 1890.

or a cholesteatomatous formation in it (Weinlechner) occasionally necessitate the opening of this cavity.*

For the treatment of swellings and increased discharge in the lower portions of the pharynx the application of astringent gargles is sufficient. If great tumefaction has taken place, subsidence of the swelling of the diseased portions will be effected either by painting with a concentrated solution of nitrate of silver, tincture of iodine or iodine and glycerine, or by dusting the parts with powdered alum applied with a brush, or with a ball of wadding held with the forceps. Hypertrophied tonsils have to be removed only when they impede the breathing or cause frequent relapses of the pharyngeal catarrh and consecutive swellings on the mucous membrane of the Eustachian tubes and of the tympanic cavity. If granulations have formed on the posterior pharyngeal wall in consequence of chronic inflammation, they must be destroyed by solid nitrate of silver, melted upon an angularly curved probe, by swabbing them with liq. ferr. muriat., or by the galvano-cautery (Michel).

Lastly, attention must be drawn to the importance of the general treatment, which in many cases is a necessary addition to the local. The presence of disorders of nutrition and constitutional peculiarities must be taken into consideration. If the patient's general condition is unsatisfactory, it must be the care of the surgeon to improve it by suitable diet, fitting occupation, frequent exercise in the open air, change of air, residence in the country, especially in mountainous districts well wooded with pines, by baths, etc. Sometimes the most obstinate naso-pharyngeal catarrhs, which have resisted all treatment, will disappear on the change of air. If syphilis exists, anti-syphilitic remedies must be employed in conjunction with the local treatment. In scrofulous cases, the use of brine or iodine baths (Ischl, Kreuznach, Reichenhall, Hall in Upper Austria, etc.) has a very favourable effect, and in such cases, especially in children, good results may be obtained by the internal administration of cod-liver oil, iron and iodine. For plethoric patients with a tendency to hæmorrhoids, treatment by mineral waters (Marienbad, Friedrichshall, Ofen, etc.) is indicated. If a tendency to catarrh exists, this disposition can be improved by the systematic use of cold baths and living much in the open air.

* McBride, *Empyema of the Superior Maxillary Antrum, etc.*, Edinburgh, 1888; and Bayer, *Contrib. à l'étude et au traitement de l'empyème de l'antre Highmore, Revue de Laryngol., de l'Otol. et Rhinol.*, 1889.

DISEASES OF THE SOUND-PERCEIVING APPARATUS (DISEASES OF THE INNER EAR).

I.—ANATOMY OF THE INNER EAR.

The inner ear or sound-perceiving apparatus comprises the central origin of the auditory nerve, the trunk of the auditory nerve, and its expansion in the labyrinth. According to the customary anatomical representation we begin with the description of the labyrinth.

A. The Labyrinth

consists of the osseous capsule and the membranous labyrinth enclosed by it.

1. *The Osseous Labyrinth*

is divided into the vestibule, the three semicircular canals, and the cochlea, to which may be added the internal auditory meatus.

a. The Vestibule forms an irregular, elliptical cavity, its vertical measure is 5 to 6 mm., transverse 3 to 4 mm., and its height 4 to 5 mm. Its walls

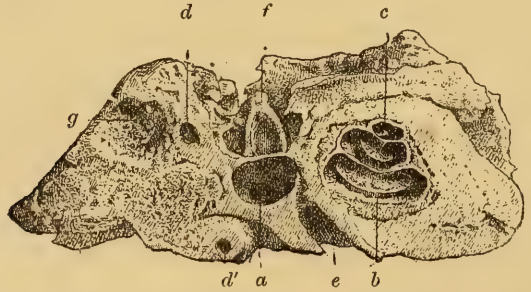

Fig. 291.—Horizontal Section through the Petrous Bone of a New-born Child. (Twice the actual size.)

a, Vestibule; *b*, Base of the cochlea; *c*, Cupola of the cochlea; *d*, *d'*, Sections of the superior semicircular canal; *e*, Internal auditory meatus; *f*, Stapes; *g*, Antrum mastoideum.

merge into each other without any well-defined demarcation. Its lateral wall, chiefly directed downwards, is formed in great part by the fenestra ovalis

closed by the footplate of the stapes, which is 3 mm. long, and 1½ mm. wide. On the median and inferior walls are placed two depressions separated by the crista vestibuli, and destined for the reception of the two saccules of the vestibule; the anterior, smaller (2 to 3 mm. in diameter), the recessus hemisphericus, and the posterior, larger (4 to 5 mm. long, and 3 mm. wide), the recessus hemiellipticus. The upper end of the crista vestibuli, lying opposite the fenestra ovalis, is called the pyramid of the vestibule. Besides the two recesses there is a small opening on the inner wall of the labyrinth—the opening of the aqueductus vestibuli, from which a grooved depression extends towards the lower ves-

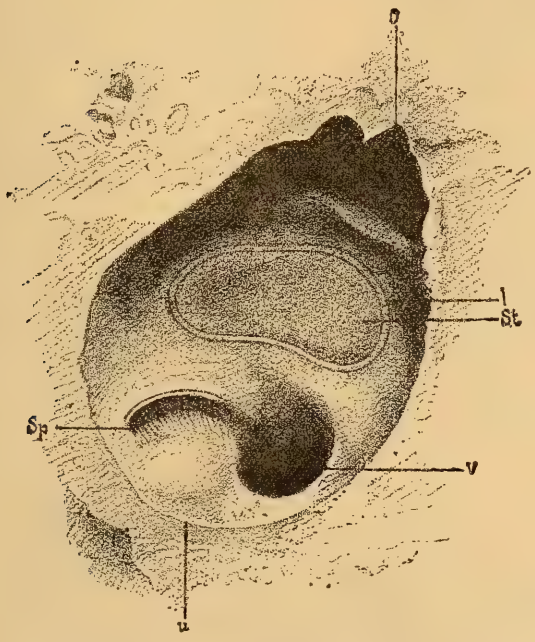

FIG. 292.—PARALLEL SECTION THROUGH THE VESTIBULE. VIEW OF ITS LATERAL WALL.

o, Upper wall; *u*, Lower wall; *st*, Fenestra ovalis with the footplate of the stapes; *l*, Ligament. orbiculare stapedis; *sp*, Beginning of the lamina spir. oss. et membranacea on the lower vestibular wall; *v*, Entrance into the scala vestibuli of the cochlea. After a preparation in my collection.

tibular wall. On the posterior, and partly also on the superior and inferior walls of the vestibule, lie the mouths of the semicircular canals, three larger ampullar orifices and two smaller embouchures. The ampullar openings of the frontal (Fig. 293, *as*) and horizontal (*ah*) semicircular canals lie near each other on the upper wall of the vestibule, above the fenestra ovalis, the frontal ampulla being above the horizontal. The ampulla of the sagittal semicircular canal (*s*) lies on the floor of the vestibule in the region of the openings of the horizontal (*h*) and the combined openings of the frontal and sagittal semicircular canals (*co*). The ampullar openings are separated from the vestibular

walls by projecting ridges—the crista ampullar. On the lower vestibular wall, below the fenestra ovalis, is the beginning of the lamina spiralis ossea membranacea (Fig. 293, *sp*) extending towards the entrance of the scala vestibuli, and with a slight bend from within outwards. On the macerated temporal bone an opening is left by the destruction of the beginning of the membranous spiral plate, through which the vestibule communicates with the lower part of the cochlea. On the anterior inferior wall is placed the entrance of the cochlea into the scala vestibuli.

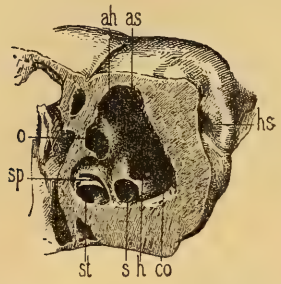

FIG. 293.—FRONTAL SECTION THROUGH THE VESTIBULE: VIEW OF THE POSTERIOR VESTIBULAR WALL. (ENLARGED TO DOUBLE ITS NATURAL SIZE.)

o, Fenestra ovalis; *ah*, Ampulla horizontalis; *as*, Ampulla superior.; *s*, Ampullary orifice of the posterior semicircular canal; *h*, Embouchure of the horizontal semicircular canal; *co*, Common embouchure of the frontal and sagittal canals; *sp*, Commencing portion of the lam. spiralis in the vestibule; *st*, Scala tymp. of the cochlea; *hs*, Hiatus subarcuatus. After a preparation in my collection.

On the crista vestibuli as well as on the floor of the two recesses are situated the so-called maculæ cribrosæ, each with a number of foramina intended for the passage of the fibres of the vestibular nerve. The macula cribrosa superior is destined for the passage of the nerves of the utricle and of the ampullæ of the anterior vertical and the horizontal semicircular canals, the macula cribrosa media for the nerves of the saccule, and

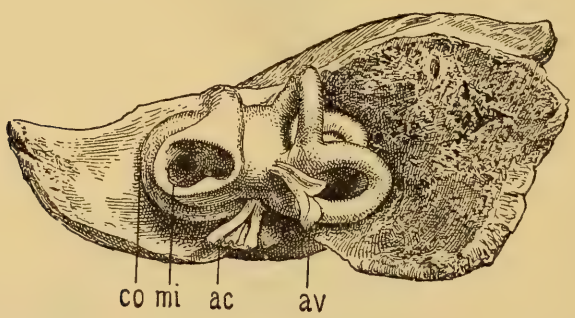

FIG. 294.—POSTERIOR VIEW OF THE OSSEOUS LABYRINTH, WITH THE THREE SEMICIRCULAR CANALS, THE COCHLEA, AND THE AQUEDUCTS OF A NEW-BORN INFANT. (ENLARGED TO DOUBLE ITS SIZE.)

co, Cochlea; *mi*, Meat. audit. intern.; *ac*, Aquæductus cochleæ; *av*, Aquæductus vestibuli.

the macula cribrosa inferior for the nerves of the ampulla of the posterior vertical semicircular canal.

b. The Semicircular Canals.—The three semicircular canals, which lie in the osseous mass of the petrous bone behind the vestibule with their planes standing perpendicularly to each other, enclose a solid angle. They are distinguished as the superior (frontal), the posterior or inner, and the horizontal

or external semicircular canal. The convexity of the superior (frontal) semicircular canal (Fig. 295, *c*) is turned towards the upper surface of the pyramid, and forms there a circumscribed bulging (eminentia arcuata), the highest point of which, however, does not correspond exactly to that of the semicircular canal. The convexity of the inner (sagittal) semicircular canal (*e*) is turned backwards, and its plane lies nearly parallel to the posterior wall of the pyramid. The convexity of the external or horizontal semicircular canal (*g*) is also turned backwards, and its external portion bulges out on the inner wall of the tympanic cavity behind the Fallopian canal.

According to the investigations of Schwalbe, the length of the semicircular canals vary greatly. The inner semicircular canal is the longest and, according to him, the relations of the sagittal, frontal, and horizontal canals is about 6 : 5 : 4. The cross-section of the semicircular canals and the ampullæ are elliptical, the lumen of the canals being largest at the point where they go into the ampullæ.

Each of the three semicircular canals begins with an ellipsoidal dilatation, 1½ to 2 mm. in size, the so-called osseous ampullæ of the semicircular canals

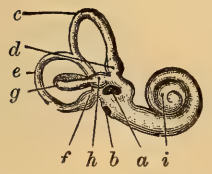

FIG. 295.—CAST OF THE OSSEOUS LABYRINTH.

a, Fenestra ovalis ; *b*, Fenestra rotunda ; *c*, Superior semicircular canal ; *d*, Ampulla of the same ; *e*, Posterior semicircular canal ; *f*, Its ampulla ; *g*, Horizontal semicircular canal ; *h*, Its ampulla ; *i*, Cochlea.

FIG. 296.—SECTION OF THE OSSEOUS CASE AND OF THE MODIOLUS OF THE COCHLEA WITH THE LAMINA SPIRALIS OSSEA.

a, Internal auditory meatus ; *b*, Modiolus.

(Fig. 295, *d*, *f*, *h*). The canals open by only two orifices into the vestibule, as the superior (*c*) and the posterior (*e*) canals before discharging unite in one common canal.

c. The Cochlea.—The cochlea (Fig. 296, *i*) presents a canal, 28 to 30 mm. long, gradually tapering towards its upper end, turning two and a half times round its axis, and on cross-section showing the form of a garden snail. In the macerated preparation the cavity of the cochlea communicates with the vestibule by a spacious opening and with the tympanic cavity by means of the fenestra rotunda.

With its spiral windings the cochlea is so embedded in the petrous bone between the internal meatus and the carotid canal, that its base is turned inwards towards the internal auditory meatus and its apex (cupola) outwards towards the tympanic cavity.

On a vertical section of the cochlea (Fig. 296), besides the cross-sections of

its spirals one sees the modiolus (*b*), which begins with a broad basis upon the internal auditory meatus and becomes gradually narrower till the neighbourhood of the cupola is reached. It is developed from a connective-tissue substance, while the cochlear capsule is formed by the primordial cartilage. Moos and Steinbrügge found full-grown cartilage cells in the cochlear capsule, and I also found cartilage elements in the supporting trabeculæ connecting the modiolus with the cochlear capsule.

The axis of the modiolus (Langer), in the direction from the base to the cupola, is traversed by numerous nervous and vascular canals. The central canal of the modiolus runs in its centre from the base to the apex: on the

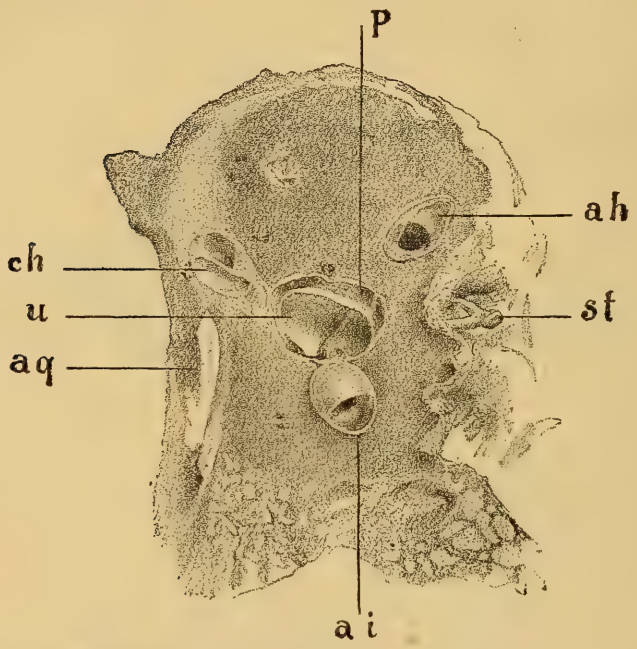

FIG. 297.—FRONTAL SECTION THROUGH THE POSTERIOR PORTION OF THE VESTIBULE BEHIND THE FENESTRA OVALIS.

u, Utriculus; *p*, Cisterna perilymphatica; *ah*, Ampulla horizontal.; *ch*, Section of the horizontal semicircular canal; *ai*, Ampulla inferior.; *st*, Stapes; *aq*, Section of the aquæductus vestibuli. After a preparation in my collection.

external surface, encircling the modiolus, runs the canalis spiralis ganglionaris (Rosenthal), which contains the ganglion spirale and avena spiralis. From the external surface of the modiolus rises the lamina spiralis ossea, a vertical osseous plate directed towards the lumen of the canal of the cochlea, which, beginning between the fenestra rotunda and the vestibular orifice of the cochlea, proceeds spirally to the cupola, and there ends in the pointed hamulus. It serves for the insertion of the membranous spiral lamina, which will be described later. By it the cochlear canal is divided into two divisions, the superior of which (scala vestibuli) communicates with the vestibule, while the

inferior (scala tympani) ends at the fenestra rotunda closed by the membr. tymp. secund. The scalæ communicate with each other at the apex of the cochlea through the helicotrema of Breschetius.

All the spaces of the labyrinth are lined by a layer of connective tissue intermixed with fine elastic fibres.

d. The Internal Auditory Meatus varies in regard to its length and width. Its course from the oval opening on the posterior surface of the pyramid is directed outwards and backwards (Fig. 291, *e*). The inner end is divided into a superior and an inferior fossa by a diagonal ledge. In the anterior part of the superior depression is situated the entrance to the Fallopian canal, and

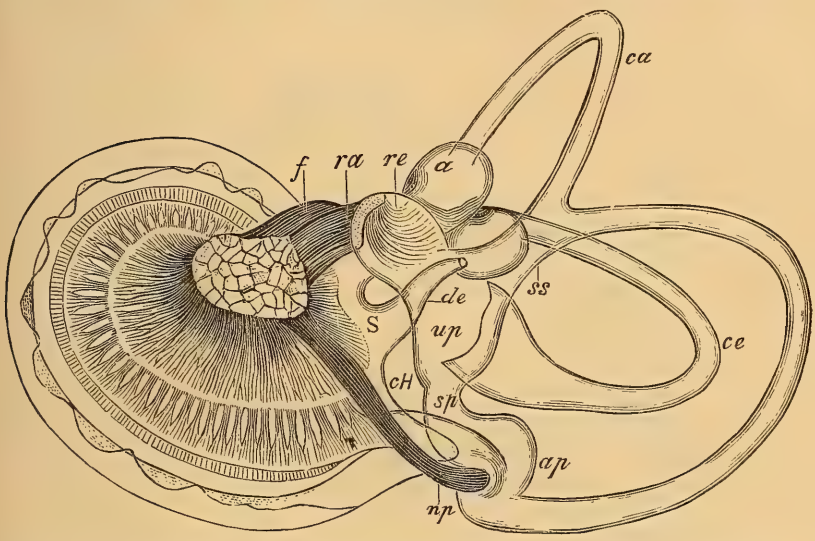

FIG. 298.—THE MEMBRANOUS INTERNAL EAR OF A HUMAN EMBRYO, 5 MONTHS OLD. ENLARGED 10 TIMES (FROM BEHIND AND WITHIN). (AFTER RETZIUS.)

up, Utric. propr. ; *re*, Recessus utriculi ; *S*, Sacculi ; *ss*, Sinus utric. superior. ; *sp*, Sinus utric. post. ; *cH*, Canalis reuniens Henseni ; *a*, Ampulla anterior. ; *ap*, Ampulla posterior. ; *ca*, Canalis semicir. ant. ; *ce*, Canalis semicir. externus ; *de*, Ductus endolymphaticus ; *ra*, Ramulus vestib. ; *f*, Nervus facialis ; *np*, Ramulus ampullæ posterioris.

in the posterior part the opening of the passage for the vestibular nerves. In the inferior fossa (fossa cochleæ, Fig. 296) are seen the spirally arranged orifices (tractus spiralis foraminulentus) at the base of the cochlea for the entrance of the fibres of the cochlear nerve. Besides, there are, on the posterior wall of the meatus internus, a small group of openings for the passage of a few branches of the ramus vestibuli.

2. *The Membranous Labyrinth.*

The membranous labyrinth, lying in the osseous capsule just described, consists of the saccules of the vestibule, the three membranous semicircular canals, and the membranous portion of the cochlea.

a. The Saccules of the Vestibule.

Of the two saccules of the vestibule, the one connected with the semicircular canals (Figs. 297 and 298) is termed the utricle, and the other communicating with the canal of the cochlea the saccule. The utricle (5 to 6 mm. long), longish in form, is embedded in the recessus hemiellipticus, and communicates immediately with the semicircular canals by five foramina. It extends from the roof of the vestibule to the entrance of the lower ampulla, and runs from the anterior superior portion downwards and backwards. It is divided

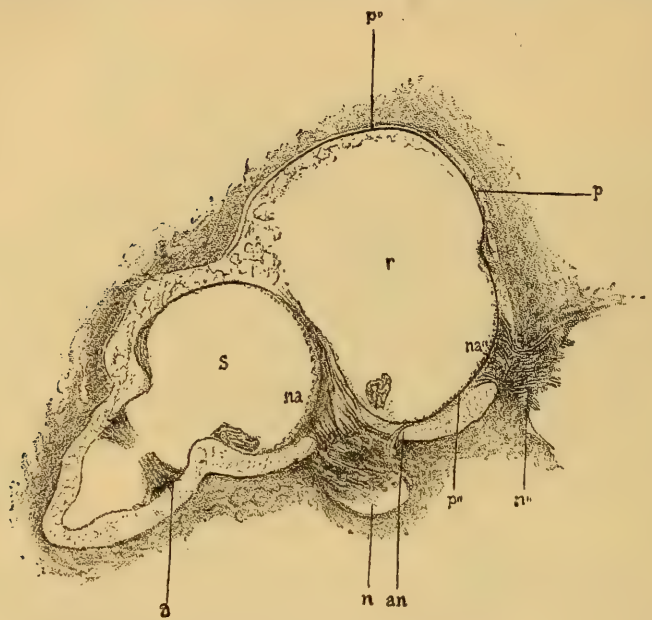

FIG. 299.—HORIZONTAL SECTION THROUGH THE VESTIBULE ABOVE THE FENESTRA OVALIS OF A NEW-BORN INFANT.

s, Utriculus; *a*, Ampulla ext. and crista ampullaris discharging into it; *r*, Upper space of the sacculus; *n*, Nerve bundles of the ramus vestibuli, passing to the utriculus and the macula acust. utric.; *p p''*, Adherent wall of the sacculus; *p''*, Anterior wall of the sacculus; *n''*, Nerve bundles passing to the macul. acust. sacculi; *an*, Nerve anastomoses running from the bundle *n* to *n''*. After a preparation in my collection.

into three sections, of which the upper, called the recessus utriculi (Fig. 298, *re*), is 3 to 3·5 mm. in breadth and length, while the second and third portions are formed by the utriculus proprius, 3 mm. long and 1·5 to 2 mm. wide. The ampullæ of the frontal and horizontal semicircular canals open into the recessus utriculi, while the ampullæ of the inner semicircular canal, the openings of the horizontal and the combined frontal and inner semicircular canals enter the utriculus proprius. On the lateral and anterior walls of the recessus utriculi is a yellowish thickening, 3 mm. long and 2 to 3 mm. wide, the macula acustica utriculi (Fig. 299, *na*, and Fig. 301, *ma*).

The rounded sacculus (s. sphericus, s. rotunda) lies in the anterior part of the vestibule in the recessus hemisphericus. This is connected with the ductus cochlearis by means of the canalis reuniens (Hensen), a tube 0·7 mm. long and 0·22 mm. wide (according to Retzius, 1 mm. long and 0·5 mm. wide). The macula acustica sacculi which lies on its medial surface is 1 to 2 mm. wide.

The sacculus vestibuli consists of a fibrillated connective-tissue layer, with a structureless, homogeneous hyaline membrane, and an epithelial layer. The connective-tissue layer is most developed on the macula acustica. The epithelial covering is formed of a simple layer of laminated epithelium (Urban Pritchard) which is composed of acoustic and filiform cells (Hasse's isolation

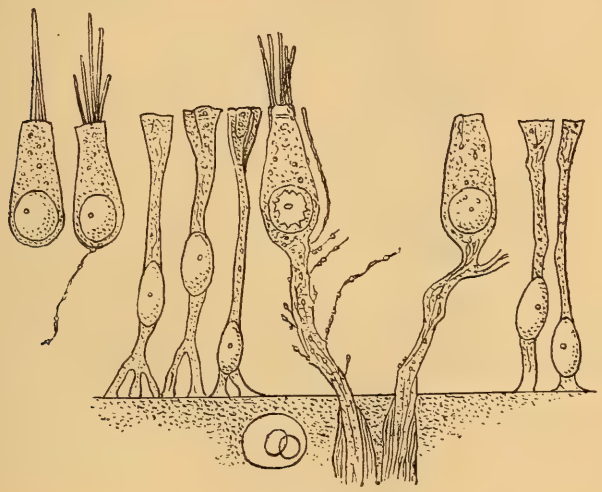

Fig. 300.

cells) together; the first are flat in shape and bulging in the middle and with a projection on the free surface. On the macula acustica the laminated epithelium is changed into a neuro-epithelium (Urban Pritchard, Fig. 300). The latter, designated as auditory cilia, consist, according to Retzius, of 10 to 15 filaments which are 20 to 25 μ long. The elliptically-shaped nucleus lies in the bulging portion of the cell. The cylindrical filiform cell possesses a rounded nucleus lying near the base. The expansion of the ramus vestibuli on the saccules takes place, according to the investigations of Urban Pritchard,* in such a manner that the medullated nerve-fibres, after anastomosing several times, spread out in the connective-tissue layer of the macula acustica, from which non-medullated nerve-filaments penetrate the hyaline layer to the epithelium, and are connected with the base of the auditory cilia (Retzius).

The neuro-epithelium of the macula acustica is covered with a clear,

* 'The Termination of the Nerves of the Vestibule and Semicircular Canals,' *Quar. Jour. of Med. Science*, 1876.

transparent, semi-fluid substance (Steinbrügge), which after death coagulates and covers the small hexagonal crystals of carbonate of lime, the otoliths, as a membrane. Schwalbe found small vacuoles in the middle of the otoliths.

The walls of the utriculus are fastened to the upper and median wall of the vestibule by means of a delicate fine-meshed connective tissue (Figs. 299 and 301). In a similar manner, the saccule is fastened to the medial wall of the

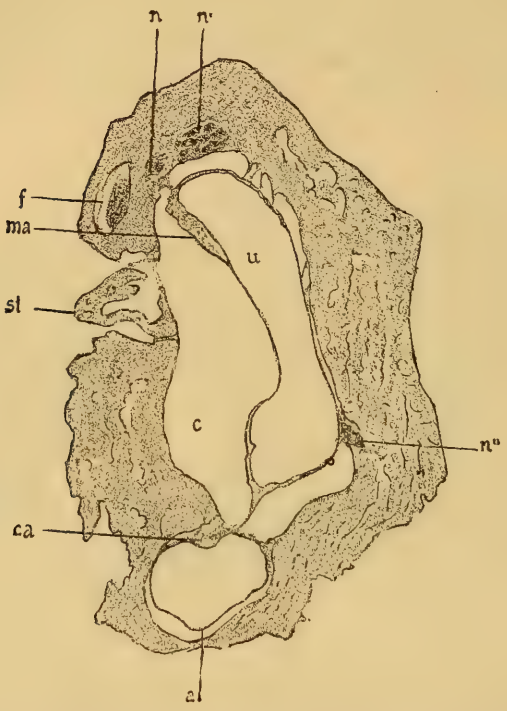

FIG. 301.—FRONTAL SECTION THROUGH THE VESTIBULE AND THE FENESTRA OVALIS OF A NEW-BORN INFANT.

u, Utriculus, attached to the medial and upper walls of the vestibule; *ma*, Free lateral wall of the utriculus; *st*, Fenestra ovalis and stapes; *c*, Cisterna perilymphatica; *n*, *n'*, *n''*, Nerve bundles of the ramus vestibuli passing to the utriculus and ampullæ; *a*, Ampulla inferior.; *ca*, Crista ampullaris; *f*, Nervus facialis. After a preparation in my collection.

recessus sphericus. Between both saccules and the lateral wall of the vestibule (Fig. 301) is a considerable perilymphatic space (Steinbrügge), which is called by Retzius the cisterna perilymphatica vestibuli.*

* To study the comparative anatomy of the membranous labyrinth I would recommend, besides the work by Retzius: *Gehörorgane der Wirbelthiere*, Stockholm, 1881 and 1884; the excellent work of Prof. Kuhn: *Beiträge zur Anatomie des Gehörorgans*, Bonn, 1880, and Prof. C. Hasse, *Die vergleichende Morphologie und Histologie des häutigen Gehörorgans der Wirbelthiere*, Leipzig, 1873.

b. The Membranous Semicircular Canals.

Their form (Fig. 302), with the three ampullary dilatations at the origin and the two openings, corresponds exactly with that of the osseous semicircular canals. By means of the latter the cavity of the ampulla is divided into two unequal parts, of which the shorter, towards the utriculus, is known as the sinus portion, the longer as the tubal portion. Besides the flat and cylindrical epithelium of the ampulla, it has on the epithelial ridge of the crista (planum semilunat.) high cylindrical cells and a neuro-epithelium analogous to that on the macula acustica of the saccule.

The membranous semicircular canals, the diameter of which is only one-third of the osseous canals, do not float, as was formerly thought, in the spaces of the osseous canals filled with perilymph, but are (Fig. 303) fastened by a

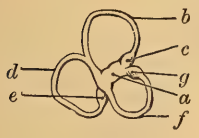

FIG. 302. — MEMBRANOUS LABYRINTH.

a, Utriculus; *b*, Superior semicircular canal; *c*, Its ampulla; *d*, Posterior semicircular canal; *e*, Its ampulla; *f*, Horizontal semicircular canal; *g*, Its ampulla.

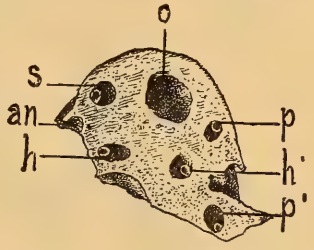

FIG. 303.—VIEW OF THE TOPOGRAPHICAL POSITION OF THE MEMBRANOUS SEMICIRCULAR CANALS WITHIN THE OSSEOUS: TRANSVERSE SECTION THROUGH THE POSTERIOR PART OF THE DECALCIFIED PYRAMID OF A NEW-BORN INFANT. (RIGHT EAR.)

s, Transverse section of the superior semicircular canal; *h h'*, Transverse sections of the horizontal semicircular canal; *p p'*, Transverse sections of the posterior semicircular canal; *o*, Fossa subarcuata; *an*, Inner wall of the mastoid antrum. After a preparation in my collection.

part of their wall to the osseous canal, consequently stationary (Kölliker, Rüdinger). From the free part of the membranous canal (Fig. 304) numerous vascular connective-tissue ligaments (*d*) proceed to the periosteum of the osseous canal. On the inner surface of the semicircular canals arise numerous papillary elevations (*c*) covered with epithelium, which are wanting on the adherent parts of the canal (*b*), and at the opening of the canals (Rüdinger). They increase considerably the superficial capacity of the semicircular canals. They are covered with a polygonal epithelium which takes a more cylindrical form on the raphe, which lies on the concave side of the canal and extends into the ampullæ. Nerve elements have not been proved to occur in these canals.

c. The Membranous Structure and the Terminal Apparatus of the Auditory Nerve in the Cochlea.

The terminal apparatus of the cochlear nerve, generally called the organ of Corti, lies on the membranous spiral lamina, which springs from the free

edge of the lamina spiralis ossea (Fig. 296) and is inserted on the projecting ligamentum spirale (Fig. 305, *l*, and Fig 306, *tr.*) of the opposite wall of the cochlea. There are three sections on the membranous spiral lamina: the inner, which is perforated in numerous places for the passage of the fibres of the cochlear nerve (zona perforata); the middle section, which bears the organ of Corti (zona arcuata); and the external finely striated portion (zona pectinata).

We have seen that the cochlear canal is divided by the spiral lamina into the scala vestibuli (Fig. 305, *s, c, v*) and the scala tympani (*s, c, t*). The scala estibuli is again divided by the membrana Reisneri (*R*) extending from the

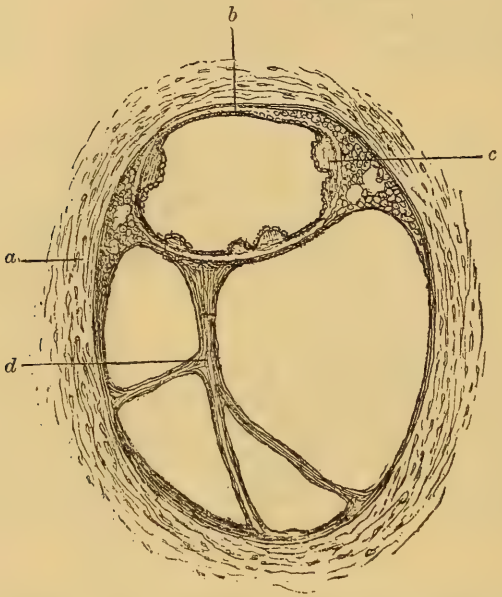

FIG. 304.—SECTION OF THE OSSEOUS AND MEMBRANOUS SEMICIRCULAR CANALS.

a, Osseous semicircular canal; *b*, Place of attachment of the membranous semicircular canal; *c*, Elevations on the inner surface of the membranous semicircular canal; *d*, Vascular connective-tissue bands.

upper surface of the lamina spiralis ossea obliquely to the external wall of the cochlea, into two divisions, of which the one formed by the membrana basilaris, the external wall of the cochlea and Reisner's membrane, is termed canalis or ductus cochlearis (Fig. 305, *Cc*). This canal, lined with epithelium and containing the proper terminal apparatus, communicates by the canalis reuniens with the saccule, and ends in a cul-de-sac at the cupola of the cochlea.

The position of Corti's organ is best seen from a profile view of a large number of vertical microscopic sections. We see (Fig. 306) on such cross-sections on the superior surface of the external section of the osseous spiral lamina, a cockscomb-like swelling (*H*) (crista spiralis, Huschke) with a toothed edge, caused by thickening of the periosteum. It roofs over a spiral

canal (sulcus spiralis int.), which is covered by a quadrangular epithelium (*K*).

The proper organ of Corti lies externally to the sulcus spiralis. It consists

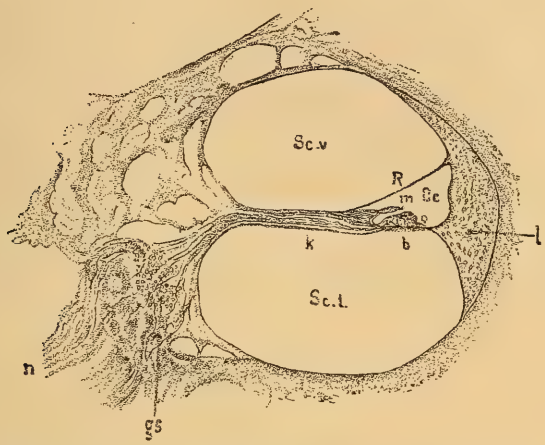

FIG. 305.—SECTION THROUGH THE LOWER CONVOLUTION OF THE COCHLEA OF A NEW-BORN INFANT.

Sc. v, Scala vestibuli; *Sc. t*, Scala tymp.; *k*, Lamina spiral. ossea; *b*, Lamina basilaris; *l*, Ligamentum triangulare; *R*, Membrana Reisneri; *Cc*, Canalis cochlearis; *o*, Corti's organ; *m*, Corti's membrane; *n*, Fasciculus of the ramus cochleæ; *gs*, Ganglion spirale. After a preparation in my collection.

of an inner (*C*) and and an outer (*C'*) layer of lightly-swung rods (Corti's fibres), the inferior ends of which stand on the membrana basilaris, while their

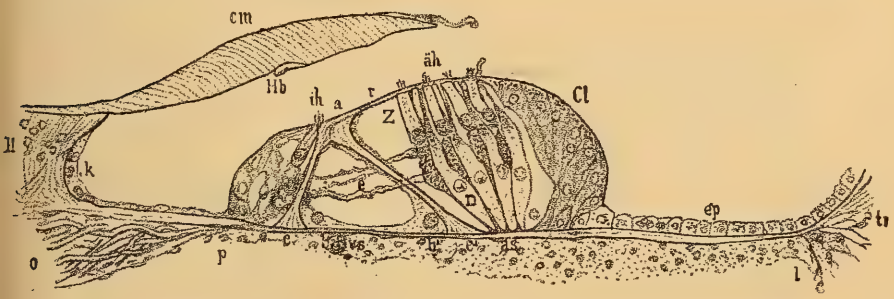

FIG. 306.—TERMINAL APPARATUS OF THE RAMUS COCHLEÆ, WITH CORTI'S ORGAN, IN THE HUMAN SUBJECT.

o, Lamin. spiral. ossea, with the nerve bundle of the ramus cochl.; *pl*, Lamin. spir. membr.; *H*, Tooth of Huschke (crista spiral.); *c*, Inner pillar of Corti; *c'*, Outer pillar of Corti; *r*, Lamina reticularis; *Z*, Corti's cells; *D*, Deiters's cells; *ih*, Inner hair-cell; *äh*, Four outer hair-cells; *e*, Radial tunnel fibres of the ramus cochl. passing to the cells of Corti; *k*, Cells of the sulcus spiralis int.; *Cl*, Hensen's supporting cells; *cm*, Corti's membrane; *vs*, Vas spirale. After Retzius.

superior ends are connected like joints. The two rows of rods form Corti's arch, the inner being wider than the outer (3 : 2). In the lower angle formed

by the rods and the lamina basilaris are two rows of round, nucleated cells (floor-cells).

The rods of the external row have on their superior ends lamelliform processes directed outwards, on which is fastened a reticularly perforated membrane, the lamina reticularis (*v*). The latter covers the external row of Corti's fibres and the so-called Corti's cells or external ciliated cells (*ah*). In man these structures lying in four to five rows behind each other (Gottstein), connected with the terminal fibres of the auditory nerve by small nervous processes, are fastened by their inferior, thin elongated ends (Gottstein's basal processes) to the membrana basilaris, while the superior, broad ends, provided with acoustic cilia, project through the openings of the lamina reticularis. A row of inner ciliated cells (*ih*) is in front of the sulcus spiralis int. immediately in front of the inner pillar of Corti's organ. Deiters's cells (*D*) are connected with Corti's cells by their broad ends directed downwards. External to the

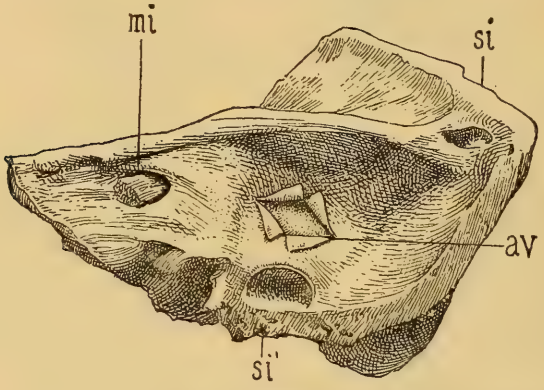

FIG. 307.—POSTERIOR SURFACE OF THE PYRAMID OF THE RIGHT PETROUS BONE OF AN ADULT, WITH THE OPENED INTRADURAL SAC OF THE AQUÆDUCT. VESTIBULI.

mi, Meat. audit. internus, with the nerv. acusticus; *av*, Opened intradural sac of the aquæduct. vestibuli; *si*, Upper section of the sinus transv.; *si'*, Its lower section. After a preparation in my collection.

last row of Corti's cells lie Claudius' and Hensen's supporting cells (*cl*) which pass into the epithelium of the external walls of the ductus cochlearis.

Corti's organ is covered by the firm, striated Corti's membrane (*cm*). The latter arises beside Reisner's membrane in front of Huschke's swelling, and ends, according to general opinion, at the external boundary of Corti's cells. According to Böttcher (*A. f. O.*, vol. xxiv.) Corti's membrane is fastened by prolongations to the surface of the terminal apparatus of the auditory nerve.

In intimate connection with the cochlea is the fenestra rotunda, situated at the back part of the promontory below the fenestra ovalis. It is closed by a slightly convex membrane, the membr. tymp. secundaria (Scarpa), which is inserted by a broad basis into the crista fenestræ rotundæ. The form of the fenestra rotunda when removed is convex above with a slightly concave base. The fibrillated lamina propria of the membrane is covered internally by a continuation of the lining of the labyrinth, externally by the mucous lining of

the tympanum (Weber-Liel), which, in the new-born, is excessively developed and, as I first observed, occasionally has one or more papillæ containing blood-vessels and visible to the naked eye.

Aquæductus Vestibuli et Cochleæ.—The aquæductus vestibuli discovered by Domenico Cutogno in 1761 arises, according to Böttcher, by two thin membranous tubes from the utricle and saccule. Both tubes unite in a single canal, 5 to 6 mm. long and 0·25 mm. wide, which enters an opening on the inner wall of the labyrinth in the narrow osseous portion of the aquæductus vestibuli. Here the tube on the hiatus aqueduct. vestibul. behind the porus acust. int. is in connection with a cul-de-sac 15 mm. long and 9 mm. wide, directed towards the sigmoid sinus and connected with the dura mater (Fig. 307), which is covered with an epithelial layer, and communicates with the endolymphatic spaces of the labyrinth (Zuckerkandl). According to Rüdinger canals branch off from the intradural sac of the aqueduct which he believes to be for the drainage of the perilymph towards the subdural lymph spaces. The aqueductus cochlea about 10 mm. long arises with a small opening in the scala tympani in the region of the fenestra rotunda and ends with a funnel-shaped opening on the lower surface of the pyramid near its posterior edge. It forms an immediate communication of the arachnoidal space with the perilymphatic fluid of the labyrinth. Coloured fluid injected into the sub-arachnoidal space penetrates into the cochlea and vestibule, according to the investigations of Weber-Liel, Schwalbe and others.

Bloodvessels of the Labyrinth.

The arteries of the labyrinth come from the art. auditiv. int. (art. acoust. central., Sapolini), running from the art. basilar., and entering the internal auditory meatus with the auditory nerve. A small branch of it enters the vestibule, supplies its lining membrane and the membranous semicircular canals, and sends smaller branches to the saccules and the ampullæ, and an arch-shaped vessel coursing along the concavity of the membranous semicircular canals. Another branch of the art. auditiva (art. cochl.) sends vessels into the modiolus (art. cent. mediolus), and into the lam. spiral. oss. on the lining membrane of the cochlear wall.

According to Böttcher (*A. f. O.*, B. xxiv) only one vessel runs in the spiral canal of the cochlea as the vas. spirale. memb. basil. (Fig. 306, *vs*), and supplies the ductus cochlearis with capillary branches. This bloodvessel with its long course and immediate connection with the terminal apparatus of the nerve in the cochlea is probably first affected in subjective noises due to a disturbance of circulation. O. Eichler* states that each turn of the cochlea possesses a separate blood current which is made up of two adjoining ones, that of the lamina spiralis and that of the wall of the scala. The artery is tortuous and

* *Anatom. Untersuchungen über die Wege des Blutstromes im menschlichen Ohrlabyrinth. Abhandlungen der König.-sächs. Gesellsch. d. Wissenschaften.* Bd. 18, 1892.

lies above Rosenthal's canal. At each turn of the cochlea, it divides into two branches; the lower goes to the vestibular surface of the lamina spiralis, while the upper ascends to the scala vestibuli, on the upper wall of which it goes to the external wall of the cochlear canal. Both arteries divide into a capillary network from which the vein is made up. This consists also of two branches, of which the upper runs on the lower wall of the spiral plate and the lower on the floor of the scala tymp. Both branches unite in the modiolus below Rosenthal's canal and form a single vein.

The Veins of the Labyrinth.—The veins of the vestibule and of the semicircular canals are collected in the vena aquæductus vestibuli, which discharges into the sinus petrosus. The veins of the cochlea discharge by means of the vena aquæduct. cochl. into the inferior petrosal sinus. The anastomosis of the labyrinthine vessels with those of the tympanic cavity is effected, as I have already pointed out, by the osseous vessels running in the external wall of the labyrinth.

B. The Auditory Nerve.

a. The Stem of the Auditory Nerve and its Distribution in the Labyrinth.

The auditory nerve, which arises from the medulla oblongata between the facial and glosso-pharyngeal nerves and enters the internal auditory meatus, is composed of two large bundles of nerve fibres from its beginning and divides into two branches at the fundibulum of the internal meatus. One branch, the ramus vestibuli, enters the vestibule and supplies with several branches the utriculus and the upper ampullæ of the semicircular canals; the second, the ramus cochlearis, the bundles of which enter the modiolus of the cochlea, sends a branch to the saccule and to the ampulla of the vertical semicircular canal (Retzius). In the root and stem of the auditory nerve are distributed a large number of ganglion cells.

Arnold describes two anastomoses between the auditory nerve and the N. intermedius Wrisbergii. According to the recent investigation of Penzo (Att. institut. Venet., 1890) those anastomoses are to be divided into a lateral and a medial. The medial consist of fibres which extend from the N. intermedius Wrisb. to the ramus vestibuli of the auditory nerve; the lateral consists of nerve fibrillæ which go from the intumescentia ganglioformis Scarpæ of the ramus vestibuli to the stem of the facial nerve.

Distribution of the Auditory Nerve in the Cochlea.—The bundle of the ramus cochleæ enters through the openings of the tractus spiral. foramin., part of it immediately into the first whorl of the cochlea and part into the nerve canal of the modiolus to the lamina spiralis ossea. On the periphery of the modiolus, between the bundle of fibres of the modiolus and the lamina spiralis ossea is a large ganglion layer (zona ganglionaris) enclosed in the oval Rosenthal's canal (Fig. 308). On the lower and medial side of Rosenthal's canal the nerve bundles (n, n', n'') enter the ganglion layer and after numerous connections with the ganglion cells enter the lamina spiralis (l) from the upper end of the canal (N).

The bundle of non-medullated nerve fibres, forming plexuses by numerous transverse anastomoses, run between the two lamellæ of bone of the lamina spiralis ossea, which are joined together by numerous bridges, as far as the Habenula perforat. on the lower surface of the basilar membrane. They then pass through numerous openings to its upper surface into the ductus cochlearis, and according to Waldeyer and Gottstein run in numerous very fine terminal fibres, enlarged in places, which are in connection with the auditory cilia.

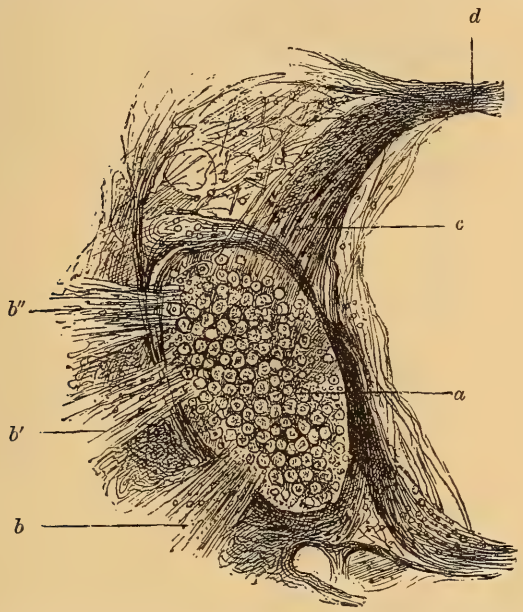

FIG. 308.—SECTION OF ROSENTHAL'S CANAL AND THE GANGLION SPIRALE.

a, Ganglion cells of the ganglion spirale lying in Rosenthal's canal; *b*, *b′*, *b″*, Three separate nerve bundles of the cochlear branch entering into the ganglion spirale; *c*, Nerve bundle coming from the superior pole of the ganglion spirale; *d*, Entrance of the latter into the lamina spiralis ossea. After a preparation in my collection.

According to the recent investigations by Retzius the end fibres of the ramus cochlea form a fine network which surrounds the auditory cilia without being in immediate connection with them.

b. Central Course of the Auditory Nerve.

The central course of the auditory nerve, over which a large number of investigators, as Stilling, Schröder v. d. Kolk, L. Clarke, Deiters, Meynert and others have laboured, appears to have been first positively discovered since the Flechsig method of studying the embryonal formation of the medullary sheath of the auditory nerve came into use. The investigators are still ununited on many important points, and most to be regretted is the fact that the results by experimentally-produced degeneration (Forel and others) differ from those of direct anatomical investigation.

In the following description I have especially followed the excellent work by S. Freud, *Ueber den Ursprung des N. acusticus*, *M. f. O.*, 1886, Nr. 8 and 9, and the accompanying figures are made from his original cuts.

The Topographical Relations of the Auditory Nerve and its Nucleus.

A transverse section through the medulla oblongata at the lowest plane of the auditory nerve (Fig. 309) through the tip of the great olivary body shows that this nerve occupies the outer area of the medulla oblongata, which extends to the great ascending root of the trigeminus (*V*) and contains the section of the restiform body. Within and above (dorsally) the restiform body lies a tract (*DK*) beautifully marked against the gray floor, which has been described as the inner portion of the pedunculus cerebelli, but which Freud considers as belonging to the auditory nerve, and calls Deiters's nucleus in the accom-

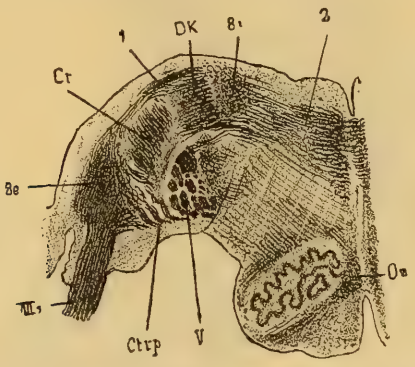

FIG. 309.—SECTION THROUGH THE LOWEST PLANES OF THE PLACE OF EXIT OF THE ACOUSTIC NERVE, FROM A HUMAN FŒTUS OF SIX LUNAR MONTHS. TREATMENT WITH WEIGERT'S HÆMATOXYLIN.

VIII$_1$, First portion of the acoustic nerve; *8e*, Outer; *8i*, Inner nucleus of the acoustic nerve; *DK*, Nucleus of Dieters; *V*, Section of the fifth nerve; *Cr*, Corpus restiforme; *Oz*, Interolivary layer; 1, Acoustic nerve-filaments round the restiform body; 2, Fibres from *8i* to the raphe; *Ctrp*, Corpus trapezoides.

panying cuts. In the outer central corner of the section lies a large nucleus of auditory nerve, the anterior or external nucleus (*8e*). The gray substance dorsally and externally from this nucleus is called the tuberculum acusticum. This is slightly developed in man, but is larger in animals, and must also be considered as an auditory nucleus.

On transverse sections, made a little higher up, bundles of the auditory nerve appear which cross the restiform body (*VIII*$_2$) and have occasioned the supposition that the auditory nerve arose in that fibrous mass. Other portions of the nerve (*VIII*$_4$), which occupy the space between the anterior nucleus and the section of the great root of the trigeminus (*V*), pass over direct into the lateral region of the gray floor (*8i*). These fibres, the most median portion of the nerve, do not belong to the auditory nerves, but to the vestibular nerve, which is connected with it. The planes in which the course of the vestibular nerve can be seen are the lowest ones of the pons. The medulla oblongata appears

to be connected here with the cerebellum through the crus cerebelli ad pontum; the roots of the facial (Figs. 311 and 312, *VII*) and of the abducens (Fig. 312) nerves occupy the inner areas of the oblongata. Deiters's nucleus (Figs. 310

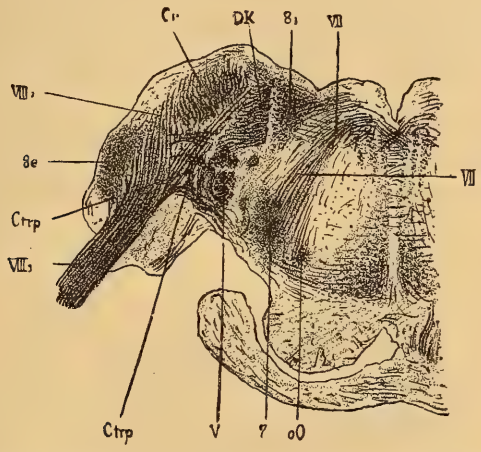

FIG. 310.—HIGHER PREPARATION FROM THE SAME SERIES OF SECTIONS, SHOWING ALSO THE NUCLEUS OF THE FACIALIS 7, AND THE FIBRES OF THE ROOT OF THIS NERVE VII, PASSING TO ITS KNEE.

VIII$_2$, The second portion of the acoustic nerve, passing round and through the restiform body; *oO*, The superior olive. The rest of the letters as in Fig. 309.

and 311, *DK*), or the inner portion of the cerebellar peduncle, can no longer be demonstrated. The fibres which it contained have curved over into the

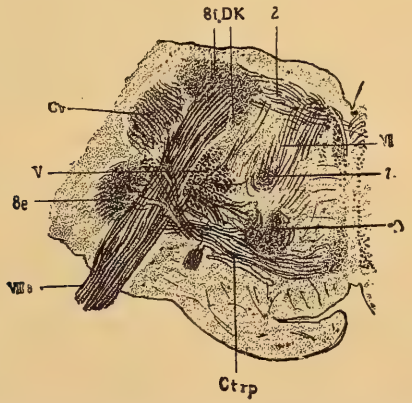

FIG. 311.—TRANSITION OF THE THIRD PORTION OF THE ACUSTICUS VIII$_3$ INTO THE FIBRES OF DEITERS'S NUCLEUS. LETTERING AS IN FIG. 310.

auditory nerve (Fig. 163, *VIIIa*, Roller). The boundary between the tegmental region and that of the pons is shown by a large cross bundle, which lies free in animals as the corpus trapezoides (Figs. 311 and 312, *Ctrp*) and may be

plainly seen in man although it is covered by fibres of the pons. It arises from the anterior auditory nucleus, is therefore a direct continuation of the auditory nerve proper and passes over the middle line. It terminates, at least in part, in a gray mass lying above it, the superior olivary body (Figs. 311 and 312, *oO*) which manifests itself through its connections as the reflex ganglion of the auditory nerve (Freud, Bechterew). Other central connections of the auditory and vestibular nerves pass as curved fibres (fibræ arcuatæ) beyond the raphe. Among these, special attention has always been directed to the so-called striæ acusticæ which are visible to a varying extent on the floor of the sinus rhomboideus. These have, however, not the significance of auditory roots, but of central continuations, probably from the anterior nucleus or from

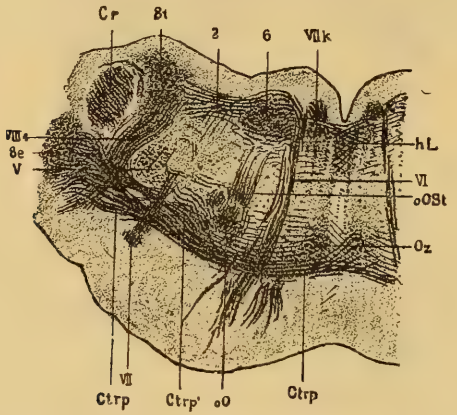

FIG. 312.—SECTION THROUGH THE PLANES OF THE FOURTH PORTION OF THE ACUSTICUS AND OF THE NUCLEUS OF THE ABDUCENS (6).

VI, The n. abducens; *hL*, The posterior longitudinal bundles; *VIIk*, Genu of the Facialis; *Ctrp'*, Portion of the corpus trapezoides, which passes to the superior olive of the same side; *oOSt*, Peduncle of the superior olive. The other letters are the same as in Fig. 309.

the tuberculum acusticum. As to the degenerative changes in the nuclei and roots of the auditory nerve produced by destroying the labyrinth, the statements of the authors vary greatly.

Origin and Central Continuations of the Auditory Nerve.

The auditory nerve is divided into two sections, of which the lateral and lower can be identified as the cochlear nerve: the inner and upper as the vestibular nerve (comp. the accompanying diagram by Freud, Fig. 313). The cochlear nerve arises from the anterior nucleus (*VK*), and in a small portion of gray substance which surrounds the dorsal and external of these nuclei, the tuberculum acusticum (T.ac). Its central continuation is well known, and has been followed for a long distance. From the median side of the nucleus (*vK*)proceeds a large transverse bundle, the corpus trapezoides (*Ctrp*), which in animals lies free in front of the fibres of the pons, but in men, however, is

covered by them. The greatest portion of it crosses the middle line and ends in the folded gray mass of the superior olivary body on the opposite side (*oO*), while a smaller portion ends directly in the superior olivary body of the same side. Both corpora trapezoid. form a beautiful decussation in the raphe (*R*). The superior olivary body, an important reflex ganglion of the auditory nerve,

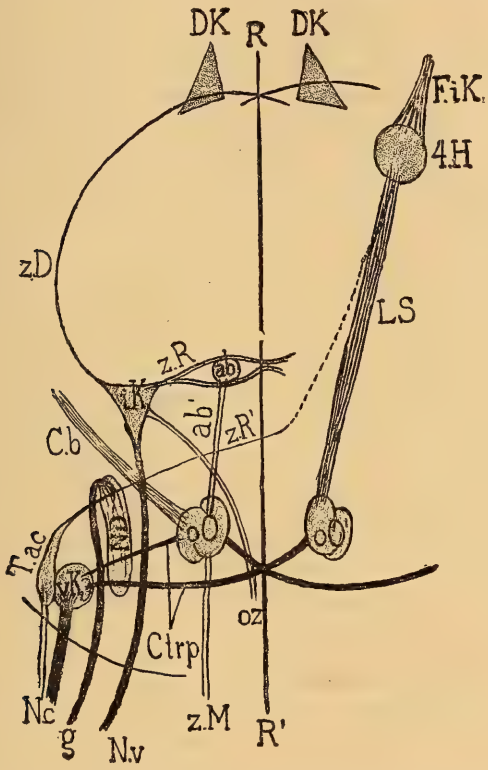

FIG. 313.—DIAGRAM OF THE ORIGIN OF THE AUDITORY NERVE BY S. FREUD.

R, *R'*, Raphe; *DK*, *DK'*, Nucleus in the roof of the fourth ventricle; *vk*, Anterior auditory nucleus; *ik*, Inner auditory nucleus; *ND*, Deiters's nucleus; *T.ac*, Tuberculum acusticum; *oO*, *oO'*, Superior olivary body; *ab*, Nucleus of the abducens; *4H*, Nucleus of the posterior corpora quadrigemina; *Nc*, Cochlear nerve; *Nv*, Vestibular nerve; *Ctrp*, Corpus trapezoides; *zR*, Fibres from the inner auditory nucleus to the raphe; *zD*, Connections between the inner auditory nucleus and the nucleus in the roof of the fourth ventricle; *zR'*, Fibres from the tuberculum acust. to the raphe and to the lateral lemniscus of the other side; *Cb*, Fibres from the superior olivary body to the cerebellum; *zM*, Fibres from the superior olivary body to the spinal cord; *ab'*, Fibres from the superior olivary body to the nucleus of the abducens; *LS*, Lateral lemniscus.

now forms further connections of the course of the auditory nerve. From each superior olivary body a large bundle extends along the side wall of the fourth ventricle to the cerebellum (*Cb*) and so gives an uncrossed continuation of the nerve to the cerebellum. Another bundle (*ab*) ascends to the nucleus of

the abducens nerve, and appears to connect the aural impressions with the movements of the eye. A third small bundle descends directly downwards to the lower planes and becomes a constituent part of the lateral columns of the spinal cord (*zM*).

The largest continuation of the auditory nerve is, however, the crossed continuation to the cerebrum which takes the following course. From the upper part of the opposite superior olivary body, at a plane which is situated higher than the entrance of the auditory nerve (right half of the diagram), a large bundle appears which forms the principal portion of the lemniscus (*LS*). This bundle extends as far as the region of the corpora quadrigemina, and ends there in the gray nucleus of the posterior corpora quadrigemina (*4H*) bulging from there out to the internal capsule (*FvK*). The continuance of the auditory nerve in the brain has been followed thus far anatomically.

From the tuberculum acusticum arched fibres proceed across the raphe as the striæ acusticæ, which are probably also joined to the cerebral continuation of the nerve.

Between the cochlear and vestibular nerves lies a portion of the nerve (*g*) which curves backwards in longitudinal fibres, exactly like the greater root of the trigeminus, and appears to end in the gray matter of Deiters's nucleus. Nothing is known of its continuation.

The vestibular nerve ends in the inner nucleus (*vK*) which lies in the region, and deeper than the nucleus of the vagus. From there we know of a crossed continuation, which surrounds the nucleus of the abducens, crosses the middle line, and probably represents the cerebral continuation of this nerve. Farther there is a spinal cord connection by means of fibres from the nucleus (*vK*), running diagonally inward and downward into the medullary layer between the lower olivary bodies (*oz*). The principal continuation of the nerve, however, goes from the external corner of the nucleus (*vK*), borders the walls of the fourth ventricle with fibres, which are raised, and ends in the central ganglion of the vermiform process of the cerebellum, principally in the nuclei of the roof of the fourth ventricle (*DK*, *DK'*).

The principal continuation of the vestibular nerve appears to be to the cerebellum, while that of the cochlear nerve is to the cerebrum.

Physiological Observations.

Sound-waves are conducted from the membrana tympani to the labyrinth by means of the footplate of the stapes; the sound-waves transmitted at the same time from the membrana tympani to the air of the tympanic cavity, and from that to the membrane of the fenestra rotunda at the cochlea are of secondary consideration compared to those which are conducted through the ossicular chain to the labyrinth.

By the transmission of sound to the fluid of the labyrinth only a slight displacement of the liquor Cotunnii is occasioned. According to the experiments of Burnett and Buck it is greater for low than for high tones, the latter scarcely causing a measurable movement in the fluid of the labyrinth.

Corresponding to the inward movement of the footplate of the stapes during

the positive phase of the sound-wave, the fluid in the labyrinth gives way especially towards the fenestra rotunda. The membrana basilaris of the cochlea, on account of the resistance at the apex of the cochlea, is thereby bulged out and expanded somewhat towards the scala vestibuli (Helmholtz). That at the same time, by sound-vibrations, a movement of the fluid through the two aqueducts of the labyrinth is effected, as Hensen affirms, is in my opinion scarcely possible, on account of the narrowness of the aqueducts and of the strong resistance in the cranial cavity.

The functions of the separate sections of the labyrinth have not yet been established, although by the labours of Helmholtz, Hensen, Ranke, Hasse, Exner, and others, great progress has been made in that direction.

Functions of the Vestibular Apparatus.—As to the function of the sacculus vestibuli, it was formerly thought that it furthered the perception of noises, while the cochlear apparatus served for the perception of tones. This hypothesis appears to be refuted by the results of experimental examinations of the vibrations of the nervous expansion in the labyrinth. Ranke, on microscopic examination of living heteropodes during the action of sound, observed the auditory cilia of the acoustic apparatus vibrating rapidly and moving towards the otoliths situated in the aural vesicle. Hensen observed in his experiments on crabs, that during the action of tones a certain number of cilia vibrated to certain tones. This experiment confirms the statement that we can perceive not only noises, but in a limited degree also tones by the terminal apparatus on the macula and crista acustica of the saccules and ampullæ, which may be regarded as analogous to the structures provided with auditory cilia in the lower animals.

The function of the otoliths may consist in the diminution of sound.

Functions of the Semicircular Canals.—The physiological significance of the semicircular canals, especially as to the function of hearing, has not yet been made out, notwithstanding numerous experimental investigations on this subject. While formerly the solid angle which the semicircular canals, standing perpendicularly to each other, form was believed to determine the capability of the organ of hearing to recognise the direction of sound, many physiologists regard these canals as of no importance for the perception of sound, but as an organ for co-ordinated movements.

The fundamental experiment, upon which the last opinion is based, was performed by Flourens. He observed, after division of the semicircular canals in pigeons and rabbits, considerable motor disturbances, which convinced him that these canals were the central organ for co-ordinated movements. It was seen from his, as well as from the later experiments of others, that separation of the horizontal semicircular canal is followed by lateral movements of the head with nystagmus and vomiting (Czermak) combined with turning of the body round its vertical axis; that after injury of the sagittal semicircular canal, pendulum-movements of the head forwards and backwards and an inclination of the body backwards take place; and that, lastly, after injury of the superior semicircular canal, the animal falls forwards.

Notwithstanding numerous control-experiments, the views as to the significance of the symptoms after injury of the semicircular canals are very different.

While Goltz, Mach, Czermak, Curschmann, Spamer, Breuer, Crum-Brown, Bechterew and Ewald look upon the semicircular canals as the organ of the sense of equilibrium, and Cyon regards them as the organ of the sense of space, and all consider the symptoms which Flourens produced by his experiments as due to injury and irritation of the semicircular canals and ampullæ, Breuer (Pflüger's *Archiv*, 1888) especially has proved by carefully opening a semicircular canal in the deaf, that chemical or thermal irritation, or simple disturbance of the semicircular canal, suffices to produce the disturbance of equilibrium.

R. Ewald* differentiates, upon the basis of experiment on animals, two divisions of the labyrinth—the auditory labyrinth ('Hörlabyrinth') and the muscular-tone labyrinth ('Tonuslabyrinth'), which is divided into (*a*) Goltz's organ of sense (semicircular canal apparatus), and (*b*) the maculæ acusticæ (otolith apparatus). According to Ewald the muscular-tone labyrinth governs not only the muscles of the whole head, and the movements of the eye, but also the movements of the body. In animals, after removing the labyrinth, an abnormal flaccidity of the limbs develops: after plugging the semicircular canals a general atrophy of the muscles takes place. Ewald also states that the stem of the auditory nerve is sensitive to the waves of sound, by which it is distinguished from the other nerves of sense, in which only the terminal organs possess this quality.

In direct opposition to the views of these authors are the data of A. Böttcher, A. Thomaszewicz and Baginsky, which lead to the inference that all disturbances after injury of the semicircular canals proceed from a simultaneous injury of the cerebellum. This view is supported by the experiments by J. Steiner (*Deutsche Med. Woch.*, 1889) on dog-fish, in which, after removal of all the semicircular canals, not the slightest disturbance of movement was observed. According to Steiner, the experiments by Breuer only show that the semicircular canals may influence the movement of the animal, but do not prove that they are necessary and indispensable for the maintenance of equilibrium. In favour of the latter view is the want of disturbance of co-ordination among the cases where all the semicircular canals are ossified, as observed by Politzer.

Moos, Löwenberg, and Politzer agree with the opinion of Lussana and Berthold, according to which the disturbance of co-ordination after injury of the semicircular canals is called forth by the reflex transmission of the irritation from the ampullary nerves to the cerebellum, so that, as Stefani and Weiss affirm, a physiological connection exists between the ampullary and vestibular nerves and certain parts of the cerebellum. This view is supported by the results of experiments by irritating or destroying the lateral lobes of the cerebellum, of the posterior part of the lobes of the cerebellum, and of the anterior part of the vermis superior cerebelli, by which the same phenomena are brought about as by injury of the horizontal, the sagittal, and the superior semicircular canals respectively. Högyes (Pflüger's *Archiv*, vol. xxxvi.) affirms that the vestibular terminations of the auditory nerve are a peculiar end apparatus which regulates, according to the position of the head

* *Physiologische Untersuchungen über das Endorgan des Nervus octavus*, 1892.

and body, the movements of the eyes and probably also those of all the muscles for the preservation of equilibrium. This view is supported by the experimental investigations by Cyon (*Recherches sur les fonctions des canaux semicircul.*, Paris, 1878), who observed, after injuring a single semicircular canal, movements of the eye in a certain fixed direction.

That those symptoms are occasioned by irritation and not by destruction of the ampullary nerves is confirmed by Lussana's experiment, in which, after careful separation of the semicircular canals without coincident irritation of the ampullar and vestibular nerves, and even after destruction of the entire labyrinth, no disturbances of co-ordination were observed. Brown-Séquard, Cyon, and Bechterew also observed, after cutting the auditory nerve, lateral and rotary movements of the eye and lateral nystagmus, while these were wanting in Schiff's experiments. Whether, also, as Brown-Séquard affirms, disturbance of co-ordination ensues after injury to the facial nerve below the place of exit from the stylo-mastoid foramen, must be proved by farther investigation.

Function of the Cochlea.—As to the function of the cochlea and of the separate parts of the complicated terminal apparatus, we have only hypotheses to go upon. Helmholtz is of opinion that the cochlea, as opposed to the vestibule and the semicircular canals, has a higher *rôle*, viz., the analysis of sound. Which part of Corti's organ, however, corresponds functionally to the layer of rods and cones in the retina, has not yet been ascertained. Helmholtz has abandoned his early idea that Corti's rods were the terminal apparatus of the auditory nerve, since more recent discoveries have contradicted it. Hasse found in birds, which possess the power of hearing musical tones and speech, that Corti's rods were wanting, while Corti's cells were developed. These cells, bearing on their upper ends auditory cilia (external and internal ciliated cells), in number estimated by Waldeyer at about 2,000, are now regarded as the terminal apparatus of the cochlea. Corradi (*A. f. O.*, Bd. xxxii.) has observed complete deafness after destruction of the cochlea in dogs. He is therefore of the opinion that the cochlea is the only organ which is capable of receiving acoustic impressions.

According to Hensen the membrana basilaris is the part of the cochlea from which the vibrations of the labyrinthine fluid are transmitted to Corti's cells. He bases this idea upon the fact adduced by him and Hasse, that the membrana basilaris is not of an equal width all over, but increases from the lowest winding of the cochlea to the cupola. According to Helmholtz, who confirms this statement, the membrana basilaris presents a system of cords corresponding to its stripes, of which for certain tones only a limited number vibrate. The perception of the high tones, therefore, is caused by the inferior section of the membrana basilaris, and the deep ones by the superior parts; and the observation made by Moos on atrophy of the auditory nerve in the first turn of the cochlea and the experiments by B. Baginsky speak in favour of this. He produced deafness for high tones, in dogs, by destroying the lower coils of the cochlea, and deafness for low tones by destroying the upper coils (*Sitzungsbericht d. Acad. d. Wissensch.*, Berlin, 1883).* The co-vibra-

* Stepanoff (*M. f. O.*, 1888) could not prove any failure of perception for certain tones after destroying the upper whorls of the cochlea.

tion of a group of fibres must not, however, be considered as isolated or clearly defined. It is more in accordance with the fact adduced by Helmholtz that, with an increasing height of tone, perception follows not in interrupted succession, but in gradual progression, probably because at every vibration of a certain group of fibres the neighbouring fibres also vibrate slightly.

Lastly, there remain to be mentioned some physiological peculiarities of the acoustic terminal apparatus.

By noises as well as by tones after-perceptions may be called forth in the ear; that is, perceptions of sound continuing for a short time after the action of the objective source of sound. Preyer remarks upon peculiar after-perceptions following the prolonged action of a tone, particularly upon the distinctly continued perception of pulsating noises. While Fechner regards after-perceptions as pictures of the memory, Urbantschitsch terms them positive after-images, being similar to the after-images of the eye. The latter observed in his experiments with low and high pitched tuning-forks, distinct after-perceptions in young people, almost never in persons over thirty. The intensity of the after-perception, which begins 10 to 20 seconds after the objective tone has ceased, and lasts sometimes $\frac{1}{2}$ to 1 minute, is always less than that of the objective tone. On the theory that these are positive after-images, it remains unexplained that they, as I have convinced myself, can only be noted in but a small number of individuals with sound ears.

The energy of the perception of the auditory nerve, as Dove first proved, is lessened after short action of the sound; the ear, as he expresses it, becomes wearied. Urbantschitsch found in his experiments that decrease in the perception takes place for the tone or group of tones which has struck upon the ear; but immediately thereafter other tones can be distinctly heard.

If a tone be conducted to both ears by means of a tube with two branches, the perception (acoustic picture), according to Purkinje and Thompson, is situated in the middle of the back of the head. More recent experiments differ a little from this, in so far as Plumendon has placed the region of perception in the forehead. Urbantschitsch, who has introduced the term 'subjective field of hearing' for this perception, found that the perception is sometimes also situated in the region of the naso-pharynx, and that the site of the subjective field of hearing varies not only in different individuals, and with different tones, but that also in the same individual distinct lateral oscillations are observed in consequence of subjective changes in the intensity of acoustic perceptions.

The statement by Urbantschitsch that the stronger perception of binaural over monaural hearing is produced by the transmission of the subjective irritation from the acoustic centre of one side to that of the other side, appears superfluous, as this may be easily explained from the known physiological law of the simulation of sense.

The symptom observed by Le Roux, that the influence of sound upon one ear (tuning-fork) increases the capability of perception of the other, has been affirmed by a series of interesting experiments by Urbantschitsch. According to my view, this is true only for a certain kind of tones and noises (for example, the tick of a watch), as the perception of a weak-toned tuning-fork in one ear is completely destroyed by the effect of a strong-toned fork in the other ear. By

this the above theory of the increase of the perception of the ear is decidedly contradicted.

The production of peculiar sensations of colour through the effect of sound as described by Chabalier Lussana, Nussbaumer, Padrono, Grazzi, Cozzolino, Baratoux,* Lehmann, Bleuler and others, and lately substantiated by Binet,† is to be considered a reflex sensation coming from the ear, which is mostly of a psycho-physiological interest.

I have now to describe a reflex symptom from the auditory nerve to the muscles of the external ear which was shown by an interesting experiment by Högyes. A number of young dogs were ranged in a row near each other, and Högyes saw at every blow upon the tuning-fork that the auricles of all the animals moved from behind forward. Reflexes upon all groups of muscles of the body may be produced by irritation of the auditory nerve, as is shown by the movement of the whole body from loud, unexpected noises. Moldenhauer could produce muscular reflexes in the newly-born, varying from a part to the whole body according to the intensity of sound. That by musical tones, or through a certain form of noises and tones, dizziness, spasm of muscles of respiration (Kosegarten), increased or retarded heart action (Dogiel, *Arch. f. Anat. u. Phys.*, 1880) may be produced, has often been observed.

Of the physiological importance of the separate nuclei and roots of the auditory nerve little is known, and we need not enter into the various hypotheses, which are based upon certain reflex-phenomena proceeding from the auditory nerve, and further upon the fact that the N. vestibuli and N. cochleæ proceed with separate roots from the medulla oblongata in sheep and horses (Horbaczewski).

Of much greater interest is the recent hypothesis based on clinical observation and experiment (Munk, Ferrier) of the existence of a sensory centre of the auditory nerve in the temporal lobe of the cerebrum at a spot, however, whose anatomical connection with the nuclei and roots of the nerve has not yet been proved. Ferrier (*The Functions of the Brain*, 1879) observed on electric irritation of the superior temporal convolution on the exposed brain of cats, dogs, and monkeys a sudden elevation of the auricle of the opposite side, and on destruction of the temporal lobe deafness of the opposite ear. Munk arrived at the same results, which indicated a decussation of the fibres of the auditory nerve in the brain, by experiments on dogs (*Acad. d. Wissensch.*, in Berlin, 1881). According to Munk, if the parts of the temporal lobe termed 'hearing-spheres' were removed, and the hearing organ of the same side destroyed, the animal would be totally deaf, and in a short time also dumb. Munk further believes, from a series of experiments, that the posterior part of the hearing-sphere serves for the perception of low tones, and the anterior section of the same in the neighbourhood of the fissure of Sylvius serves for the perception of high tones. That on the upper surface of the cerebral hemisphere there is no centre directly connected with the auditory nerve, follows from the experiments of Goltz, who, after destroying the cortex, observed no alteration in the hearing.

* Comp. Baratoux, *L'Audition coloriée*, Paris, 1888.

† *Revue des Deux Mondes*, 1892.

II. DISEASES OF THE LABYRINTH, OF THE AUDITORY NERVE AND OF THE CENTRAL COURSE OF THE NERVE.

Introduction.

The great advance in our knowledge of the pathology of the external and middle ears within the last ten years has not been equalled by that made in the pathology of the internal ear. On the contrary, our knowledge of the anatomical changes and the diagnosis of the diseases of the internal ear is imperfect still, notwithstanding the considerable number of interesting clinical and post-mortem observations made in recent times. The reason for this is that we have rarely an opportunity of making a thorough anatomical examination of the ears of those who, having been clinically examined during life, present the phenomena of an affection of the nervous apparatus. Therefore it is that we possess, on the one hand, a series of interesting clinical observations of diseases of the inner ear, without being able to refer them with certainty to their anatomical changes; and, on the other hand, we have a large series of interesting post-mortem appearances of the internal ear, of which but a very small fraction refer to cases which were carefully examined during life.

Hence the great difficulty of a description of the diseases of the internal ear, which would in a very small measure correspond to the clinical necessity, and, therefore, a satisfactory study of the subject can only be made when by more numerous post-mortem investigations clinical observations can be brought into harmony with the anatomical changes. In the present incomplete state of our knowledge we must confine ourselves to the consideration of the diseases of the nervous apparatus partly on its anatomical and partly on its symptomatic side, without being able to assert that the anatomical and symptomatic bases overlap each other on every side.

The diseases of the internal ear are divided into primary and secondary affections. The primary affections—so far as can be judged—are out of proportion more rare than the secondary ones. Among the earlier observers nervous deafness formed a large percentage of their cases, as they classed all disturbances of the hearing, in which the examination of the membrana tympani and of the Eustachian tube gave a negative result, in the category of primary diseases of the auditory nerve (comp. Kramer, *Ohrenkrankh.*, 1849). By the important investigations of Toynbee, however, the territory of 'nervous deafness' was considerably contracted, as in the majority of such cases with negative objective appearances the

cause of the disturbance of hearing was referred to anchylosis of the stapes.

Diseases of the acoustic apparatus occur idiopathically without a known cause, or are caused by external influences (cold, sunstroke, plunges into the water, injury, concussion) or by general and organic diseases. It is in the train of affections of the middle ear, however, that pathological changes specially develop in the internal ear. They must not always, however, be taken for secondary processes in the labyrinth and in the auditory nerve, for without doubt the affection of both sections of the ear may be frequently due to the same cause.

Where this occurs in acute middle-ear inflammation, it may be due to increased pressure in the labyrinth, or to a disturbance of nutrition of the inner ear (hyperæmia, ecchymoses, serous infiltration of the membranous structure, increase of the labyrinth fluid), which is transmitted by the anastomoses through the external labyrinthine wall from the middle ear to the labyrinth.

The affection is characterized by great deafness with loud subjective noises, sometimes also combined with giddiness and disappearance of perception for the acoumeter and the tuning-fork through the bones of the head.

More frequently functional disturbances within the region of the auditory nerve are found in chronic, non-purulent affections of the middle ear. In the secreting forms the labyrinth, with few exceptions (to which belong particularly syphilitic catarrhs), remains intact. In the adhesive processes, on the other hand, particularly in the slow forms ending in anchylosis of the stapes, which develop without previous secretion, disturbances within the range of the auditory nerve appear not only after long duration, but frequently at the very beginning, and these may be regarded as simultaneous affections caused by the same trophic disturbances.

More rarely are functional disturbances in the apparatus of the auditory nerve (decreased perception of the nerve and subjective noises) observed in the purulent perforative inflammations of the middle ear, and yet anatomical changes in the labyrinth appear more frequently in these processes than, judging from the clinical phenomena, one would expect. Particularly in those suppurations in which the spongy substance of the pyramid of the petrous bone in the neighbourhood of the capsule of the labyrinth is affected with caries, extravasations of blood are found in the semicircular canals and in the cochlea, while during life no remarkable functional disturbances indicated the presence of such great changes. That by direct extension of the middle-ear suppuration to the labyrinthine

capsule, the labyrinthine cavity may be opened, and the membranous structure of the inner ear included in the inflammation and destruction has already been described.

Frequent causes of deafness from primary disease of the auditory nerve are those general and infectious diseases, such as typhus, intermittent fever, scarlatina, measles,* diphtheria, influenza,† osteo-myelitis infectiosa (Steinbrügge), syphilis, leucocythæmia, diabetes, Bright's disease, parotitis epidemica, which lead to disturbances in the centres or in the expansion of the auditory nerve, by the action of morbid blood.

In judging of so many disturbances of hearing it is of importance to note that amongst the nerves of sense the auditory nerve is the most 'impressionable,' that is, its function is more frequently impaired by general diseases and by chemical changes in the blood in infectious diseases than that of the optic, the gustatory, the olfactory, or the sensory nerves. The anatomical changes in the auditory nerve apparatus in the infectious diseases are, however, little known. In some cases hyperæmia and ecchymosis, in others small-celled infiltration of the membranous labyrinth, and in variola true suppuration (Moos), have been observed. Moos proved the entrance of micro-organisms into the labyrinth in diphtheritic ear affections.

There have been a large number of observations of rapidly occurring paralysis of the auditory nerve with complete deafness following mumps (parotitis epidemica), without being able to prove the anatomical cause. This incurable disease of the auditory nerve occasionally occurs after parotitis without fever and without dizziness. The hypothesis that an acute exudation or metastasis in the labyrinth (similar to the affection of the kidneys, ovaries, mammæ, testicles), or an affection of the acoustic centre, produces the deafness in mumps is without any foundation. That in the deafness with mumps we have to do with an infectious disease (Lannois) is very probable.

Of the pathogenic micro-organisms the streptococcus, more rarely the staphylococcus (Moos), and in the case of meningitis, also the diplococcus of pneumonia (Schwabach) have been found. The means of invasion of the micro-organisms from the cranial cavity to the labyrinth are, the aqueductus vestibuli and aqueductus cochlea, and, according to Moos, especially the periosteal bloodvessels of the aqueductus vestibuli. The micro-organisms which have entered the labyrinth either produce a rapid destruction of the connective-tissue elements, or produce, through formative irritation, the new

* Moos, *Untersuchungen über Pilzinvasion des Labyrinths im Gefolge von Masern*, Wiesbaden, 1888.

† Lannois, *Surdité labyrinthique consécutive à la grippe.* (J. Moure, *Revue de Laryngologie et d'Otologie, etc.*, Paris, 1890.)

growth of connective tissue and bloodvessels, resulting in the formation of bone. Besides, in measles in simple and scarlatino-diphtherias, the micro-organisms produce, within the bloodvessels, thrombo-arteritis and phlebitis with their results, of which is to be mentioned hæmorrhages in the region of the course of the nerve with its destruction. The destruction within the osseous tissue, Moos explains, through the entrance of microbes into the periosteum and bone corpuscles.

It is also known that the auditory nerve is more frequently affected by medicines circulating in the blood than the other nerves of sense. It is necessary only to mention the well-known effects of quinine, salicylic acid, morphia, and chloroform, which exercise a temporary, but often also a lasting, influence on the function of the auditory nerve, as in large doses or after long use they give rise to subjective noises and deafness, and much more rarely to blindness. The effect of quinine manifests itself first in the production of subjective noises, and only after 1 to 3 hours in a diminution of the hearing. Chronic lead intoxication can produce labyrinth deafness (Triquet).

According to Kirchner (*Berl. klin. W.*, 1881), who after feeding rabbits with quinine found hyperæmia and hæmorrhage in the mucous membrane of the tympanic cavity and in the labyrinth, the pathological changes in the ear caused by quinine or salicylic acid may rank as vaso-motor disturbances, which bring about engorgement and exudation in the ear.

Of organic diseases those of the brain and its membranes are most frequently accompanied by disturbances of hearing, especially epidemic cerebro-spinal meningitis, hydrocephalus, acute and chronic encephalitis, cerebral tumours, less frequently diseases of the spinal cord. These are due either to the transmission of inflammatory processes from the cranial cavity to the labyrinth and the trunk of the auditory nerve, or to pressure on the auditory nerve and the bloodvessels supplying the labyrinth, and lastly to those diseases of the brain and medulla oblongata by which the nuclei and roots of the auditory nerve are drawn within the range of the disease. Temporary or permanent disturbance of hearing have also been observed with epilepsy.

Disturbances of function are further caused by stoppage of the circulation of the blood in the vessels of the head. In this case the anomalies of hearing may be traced to diseases of the heart and lungs, and to many forms of struma.

It was known to early writers that disturbances of hearing occurred in the course of affections of the stomach, liver, kidneys, and uterus. On the whole, however, according to my experience, this is much seldomer the case than is generally supposed; for I have often found in cases in which there was supposed to be a

connection between the organic disease and the ear affection, that the fundamental cause is palpable changes in the middle ear. But even in the case of admitted disease of the auditory nerve, it must not on that account alone be connected with the organic disease, for aural and organic diseases may develop quite independently of each other. Notwithstanding, interchanges between those organic diseases and the organ of hearing cannot be denied. It has not yet been proved whether they, as is supposed, are caused by reflex transmission through the vagus and the spinal cord, or by changes in the sympathetic nerves. Certain it is that in a series of cases in the course of chronic organic diseases general disturbances of nutrition are developed in the organism, such as anæmia, hydræmia, and marasmus, of which the deleterious influence on the whole nervous system is well known, and which doubtless, by acting on the slightly resistant auditory nerve, may occasion an irritation or paralysis of it.

There may be found in the earlier writers allusions to the connection between certain organic diseases and ear affections. Sand (cited by Lincke) observed that in a man suffering from a gastric ulcer the pain radiated from the stomach to the ear. On the same authority Hippocrates is said to have proved the connection between disease of the liver and affections of the right ear. The connection between the uterus and the ear, also, which has received great attention in recent times, is said by Lincke to have been known to early physicians (Ebersbach, 1725; Lanzoni, Gohl). In recent times there are observations on the same subject by Scanzoni, Benni (Warsaw), Gellé, Baratoux, and others. In several cases of suppressed menstruation Benni observed a vicarious exudation and bleeding from the middle ear. Baratoux (*Des Affections auriculaires et de leurs Rapports avec celles de l'Utérus*, Paris, 1881), from his own and Gellé's observations, comes to the conclusion that in the presence of purulent inflammation of the middle ear the occurrence of menstruation may aggravate the local affection, and in amenorrhœa vicarious bleeding from the ear may occur. Moreover, in consequence of suppressed menstruation and at the menopause cases of giddiness are observed associated with subjective noises and vertigo, which can be traced to an arterial fluxion in the vessels of the labyrinth. It is known that disturbances of hearing, or permanent impairment of it, may occur during pregnancy and after parturition.

Transient or permanent functional impairment of the auditory nerve may be produced by traumatic effect upon the skull (violent fall, blow, concussion), and by the effect of intense sound (explosions, detonations). That a sudden difference in the air-pressure can produce deafness is proved by a case observed by Moos, in which sudden deafness occurred a quarter of an hour after leaving the diving-bell.

Lastly, mental affections may also cause diseases of the auditory nerve apparatus. Although on the whole rare, such occurrences have been confirmed by experience (Dalby, Bürkner, Urbantschitsch), and in my own practice I have observed several cases of temporary or permanent tinnitus or of deafness caused by fright; for example, by an alarm of fire or by sudden grief. This is easily understood when one considers that mental affections are among the most powerful irritants of the vascular nerves (the constrictors and dilators of the vessels), that consequently, by a sudden disturbance of the circulation of the auditory nerve and its expansion, disturbances of nutrition (ischæmia, hyperæmia, stasis) may be brought about, manifesting themselves by symptoms of irritation or of paralysis.

Hereditary predisposition to diseases of the auditory nerve, as the numerous cases of inherited deafmutism prove, cannot be denied. On the whole, however, it is less commonly of etiological moment than in the affections of the middle ear.

Diseases of the internal ear occur more frequently in children than in adults. This is explained by the frequent occurrence in childhood of those forms of disease which are so frequently complicated with ear disease, such as the acute exanthems, acute hydrocephalus, epidemic cerebro-spinal meningitis, etc. Further, as an important anatomical element in the causation, it must be mentioned that the anastomotic connections between the middle ear and the labyrinth on the one hand, and between that and the cranial cavity on the other, are more numerous in children than in adults; and further, that in the child's ear through the aqueducts there is a greater communication between the labyrinthine fluid and the cerebro-spinal cavity than in that of the adult. For this reason, as clinical experience shows, inflammatory processes in the middle ear and in the cranial cavity are much more frequently transmitted to the labyrinthine cavity in children than in adults. That the auditory nerve in childhood offers less resistance in febrile and infectious diseases than in later years has been placed beyond doubt by clinical observation.

While in middle age the frequency of diseases of the auditory nerve diminishes, in old age it again increases. As the anatomical basis of these disturbances of hearing in old age, I have often found besides the peculiar changes in the osseous tissue of the pelvis ovalis which produce anchylosis of the stapes, retrograde changes in the auditory nerve and in its expansion (senile metamorphosis), atrophy, fatty degeneration, deposition of corpora amylacea, and chronic endarteritis.

The frequent occurrence of affections of the labyrinth in certain occupations, as in artillerymen, riflemen, smiths, locksmiths, coopers, etc., in consequence of intense or continued action of sound, has already been mentioned.

Affections of the auditory nerve attack, in the majority of cases, both organs of hearing, either simultaneously or at a shorter or longer interval. Disease of the auditory nerve is rarely localized permanently in one ear. According to my experience this is oftenest the case in unilateral paralysis of the nerve caused by a violent noise. As in affections of the middle ear, so in unilateral affections of the nerve, the danger of transmission to the other ear is the greater the higher the degree of disturbance of hearing. Similarly in cases in which disease of the formerly normal ear is added to a unilateral deafness, there is an unusually rapid decrease in the function of hearing. In what way the affection of one ear proceeds to the other has not yet been proved. The anatomical fact that the root-fibres of the one auditory nerve pass over into the external auditory nucleus of the other side (Meynert), permits the assumption that probably degenerative processes of the one auditory nerve may seize upon the centre and stem of the nerve of the other side.

The symptoms of affections of the auditory nerve manifest themselves partly as irritative phenomena, among which are reckoned first subjective sensations of hearing, then hyperæsthesia acoustica, giddiness, vomiting, and disturbances of equilibration, partly as paralysis-phenomena, consisting in diminution of the sharpness of hearing, in change of sound-perception, or in total deafness. In most cases symptoms of paralysis and irritation are combined. Disturbances of co-ordination may be lacking in extensive labyrinth affection (Eckert).

The disturbances of hearing in the affections of the internal ear develop sometimes very quickly and sometimes very slowly. In some forms of disease, as in apoplectiform Menière's disease, labyrinthine syphilis, cerebro-spinal meningitis, and in traumatic concussion of the labyrinth, the function of hearing is often quite suddenly or within a few days totally destroyed. In other chronic forms, on the other hand, particularly in those slow processes with retrograde changes in the auditory nerve and in the labyrinth, which, as we have seen, so often develop in the chronic adhesive processes in the middle ear, the hearing gradually but irregularly decreases. Long stationary intervals may follow a period in which the deafness progressively increases, or the slow course may be interrupted by sudden exacerbations.

The oscillations in the acuteness of hearing are generally slighter

and less frequent in affections of the auditory nerve than in affections of the middle ear. Among causes affecting these are external influences, bodily illness, mental excitement, night-watching, strained attention while hearing (Toynbee), the use of alcoholic liquors, etc.

The subsequent conditions and terminations of diseases of the internal ear depend partly on their cause and partly on the intensity of the pathological changes. That a series of pathological processes in the labyrinth and in the auditory nerve may recede with complete re-establishment of the function of hearing is placed beyond doubt by clinical observation. On the whole, however, return to the normal state is rarer than in the affections of the middle ear. This is sufficiently proved by the slight resistance offered by the auditory nerve, particularly by its terminal organ in the labyrinth, to the action of disease-products. Hyperæmia in the labyrinth, the serous saturation of its structures, and probably small-celled infiltration also, may recede without leaving a disturbance of hearing behind. On the other hand, from clinical observation it is very probable that deep-seated changes, such as purulent inflammations, great effusions of blood, extensive invasion of cocci, retrograde changes, etc., lead to a more or less rapid incurable disorganization of the auditory nerve with destruction of the function of hearing.

The prognosis of affections of this nerve depends on their cause, their duration, and intensity. It is unfavourable in the majority of cases. This applies particularly to sudden apoplectiform deafness, high degrees of affection of the nerve developing in the train of infectious diseases, cerebral disturbances of hearing, and slow affections of the labyrinth complicated with sclerosis of the mucous membrane of the middle ear.

A more favourable prognosis, on the other hand, is permitted in recent rheumatic paralysis, in recent paralysis due to medicines, in many forms of hysterical deafness, in slight concussions of the labyrinth, and in a limited sense in syphilitic affections of the latter.

Diagnosis of the Diseases of the Auditory Nerve.

The study of affections of the auditory nerve presents great difficulties in a considerable number of cases. This applies not only to the differential diagnosis between diseases of the middle ear and of the nervous apparatus, but also to decided affections of the nerve, in so far as it is often impossible to determine whether the disease is in the labyrinth, in the trunk of the nerve, or in its central course. Moreover, it must be remembered that affections of the middle ear

and of the labyrinth are frequently combined, and that in such cases it cannot be determined what portions of the symptoms present and of the disturbance of hearing are to be attributed to the affection of the middle ear, and what to the disease of the labyrinth.

The diagnosis of affections of the auditory nerve depends chiefly on a consideration of certain symptoms and disturbances of hearing and on the result of the functional examination. The latter is the most important, as Lucae rightly observes, because in most cases the detailed functional examination gives the first indication of an affection of the nerve.

To test the function of hearing we use the watch, the acoumeter, various tuning-forks, Galton's whistle, König's sounding bars, and lastly also speech. For the details of this examination the reader is referred to the Tests for Hearing; the following are the results of the functional examination in diseases of the auditory nerve.

Testing with the watch and acoumeter in disease of the auditory nerve, also gives us no indication of the hearing-distance for speech. In general, however, speech is heard at a relatively greater distance in slight degrees of deafness. A diminished perception for the ticking of a watch through the cranial bones cannot be considered as a symptom of a disease of the auditory nerve.* Where, however, a loud sound (for example the acoumeter) is only faintly heard through the cranial bones or not at all, it is probable that there is a disease of the auditory nerve apparatus, without being able to say whether it is primary or is combined with a middle-ear affection.

Testing with tuning-forks is indispensable for the diagnosis of diseases of the auditory nerve. As the perception for high and low tones quite frequently appears altered, it is necessary to use tuning-forks of different pitch to test the hearing.

Bonnafont (*Compt. rend. de l'Acad. des Sciences*, May, 1845) first called attention to the fact that, in nervous deafness the perception for high tones is first diminished, while low tones are still well heard. This statement was confirmed by Moos and Lucae from the results of dissecting some cases of labyrinth disease which had been examined during life.

Of special diagnostic importance is testing with low-toned tuning-forks, in so far that their perception in the higher grades of deafness forms an important link in the chain of diagnosis. On the other hand, testing with high tones is of only slight value, as very frequently, even with marked labyrinth affections, they are still perceived to nearly the upper limit of the scale.

* This is only true for individuals who have not passed sixty years of age.

Lateralization of the tone of a tuning-fork placed upon the vertex (Weber's test) in the normal ear, is only of value in the diagnosis of labyrinth disease when at the same time the result of Rinne's test, the test for the perception of high and low tones, and the whole combination of symptoms speak for a disease of the nerve.

In a similar manner the positive result with Rinne's test can only be used in connection with the results of other methods of testing for the diagnosis of auditory nerve affection.

A remarkably short duration for perception of the C^2 tuning-fork (Schwabach's test) is an important point with the above methods for proving a disease of the auditory nerve.*

Gellé's test is only of value for diagnosis when with severe deafness, even upon a moderate centripetal pressure, severe dizziness and an increase of the tone of the tuning-fork from the vertex occurs. Both may be absent in marked diseases of the labyrinth.

The diminished perception for the tuning-fork through the cranial bones only precludes a restitution of the hearing in chronic ear affections (Bonnafont); in recent labyrinth disease healing may occur in spite of the failure of bone-conduction.

The result of testing with musical tones frequently coincides with the tuning-fork examination, but not uncommonly the results of testing with the different forms of musical instruments, for the better perception of low or high tones, are entirely opposite.

For proving partial tone defects, Bezold's series of tuning-forks are recommended in connection with Galton's whistle.

Moos observed in an orchestra leader, following a concussion of air upon both ears, sudden deafness for low tones (bass-deafness); Schwartze saw permanent loss of perception for high tones and, later, complete deafness in a musician (Robert Franz), due to the whistle of a locomotive; Bernett saw deafness for high tones above C^3 in a woman, aged 44, who had suffered with otalgia since childhood; and Gottstein a lack of perception for high tones from $\overline{\overline{C}}$ upwards in a man aged 47. In an orchestra leader, aged 51, examined by me, in whom one year previously ringing and roaring and, later, attacks of giddiness occurred, total deafness rapidly developed first in the right and then in the left. The previous testing with musical tones showed that the patient could hear only the low tones with the left ear, but with the right could hear the whole scale, except in the middle where h and f were completely lacking. Knapp observed deafness for a group of tones in several cases of

* Urban Pritchard (*Handbook of Diseases of the Ear*, London, 1886) uses the small tuning-fork of Gardiner Brown, with which the difference in time is measured between which the patients hear the tuning-fork and the physician fails to feel the vibration with his finger. If the patient hears the tone longer than the examiner can feel the vibration, the disturbance in hearing must be from a hindrance to sound-conduction, while the earlier disappearance of the tone signifies a disease of the labyrinth.

Menière's disease. The failure of single tones in the middle of the scale is, however, very rare. If in such cases the ear is provided with the corresponding Helmholtz's resonator, one seldom finds a complete deafness, but only a diminished perception for that particular tone. Tone defects are frequently found at the upper end of the scale, more rarely at the lower end. Bezold observed in some cases of total deafness perception for single tones of high pitch, which he designates as auditory islands (Hörinseln). Although tone-defects probably signify a disease of the auditory nerve, yet they do not preclude the presence of a hindrance to sound-conduction. This is shown by a case described by Magnus (*A. f. O.*, ii.), in which the tones F, F♯, G, G♯, A♯, H in the affected octave were not heard, and the anatomical examination of the ear, post-mortem, showed an anchylosis of the stapes with calcification of its footplate. In regard to the finer changes in the labyrinth the details are wanting.

Jankau (*A. f. O.*, Bd. xxxiv.), who again took up the method of examination proposed by me with the three-armed auscultation-tube (*A. f. O.*, Bd. i.) found, in cases of unilateral labyrinth affection, that upon testing with the double otoscope the tone of a tuning-fork placed upon the vertex was objectively more faintly heard from the diseased side, while in hindrances to sound-conduction the results conform with those of Lucae and Politzer, the tone from the affected ear being louder to the examiner.

Testing for the hearing of speech is only of slight value for the diagnosis of a labyrinth disease. According to O. Wolf, failure to hear F, R lingual, and whispered U in connection with other results of testing, speak for a disease of the auditory-nerve apparatus. Total deafness for speech is no sure sign of auditory nerve paralysis, as cases occur in which, after using the air douche, or the application of an artificial membrana tympani, the previous complete inability to understand speech at a short distance disappears, the deafness being partially produced by increased labyrinth-pressure from the tympanic cavity. In spite of that, total deafness for speech with a series of other symptoms forms an important fact in the diagnosis of a labyrinth disease.

The examination of the membrana tympani and Eustachian tube is only of diagnostic value in recent cases and with a negative condition of the membrana tympani. If one finds in recent, suddenly occurring deafness of a high degree, that the membrana tympani is normal and the Eustachian tube quite free, it is very probable that the cause of the disturbance of hearing is a disease of the auditory nerve, especially if at the same time the other results of testing go to show it. In chronic cases the normal appearance of the membrana tympani, and the Eustachian tube offers no point for diagnosis, as frequently changes in the membrana tympani and Eustachian tube may be absent in anchylosis of the stapes. On the other

hand, visible changes in the structure of the membrana tympani is no absolute criterion for the existence of a hindrance to sound-conduction, as occasionally the cause of the disturbance of hearing, in spite of the pathological condition of the membrana tympani, is in the labyrinth and not in the tympanic cavity.

Contrary to the former statement that in diseases of the auditory nerve no change occurred upon inflating the middle ear, I found that in cases where the whole combination of symptoms showed an affection of the auditory nerve, an increase, sometimes a decrease, in the hearing-distance occurred after the air-douche. This is explainable if one considers that through the change in tension in the middle ear from the air-douche, variations of pressure in the labyrinth are produced, which without doubt exercise an influence upon the hearing. Usually the change in the hearing-distance, in diseases of the auditory nerve, after an inflation of air is very slight.

Condensation and rarefaction of air in the external meatus have only a slight influence upon the hearing-distance in auditory nerve affections.

Diagnostic Value of the Labyrinthine Symptoms.—The diagnostic interpretation of the subjective symptoms in affections of the auditory nerve is beset with difficulties, when we have to determine whether they are caused by a primary affection of the nerve, or secondarily by an affection of the middle ear, or lastly by an affection of the brain. We have seen that, in affections of the middle ear also, violent noises in the ears, disturbances of hearing, dizziness, and disturbances of equilibration may be called forth by hyperæmia transmitted to the labyrinth, or by increase of pressure in consequence of clogging of the fenestræ of the labyrinth, and that similar symptoms may also occur in diseases of the brain. Consequently the so-called labyrinthine symptoms—dizziness, disturbance of equilibrium, vomiting, hyperæsthesia acustica, etc.—can therefore only be used for the diagnosis of a labyrinth affection if on one side a middle-ear affection and on the other a disease of the central nervous system can be eliminated by the examination.

In conclusion, it is of importance to note that in all cases of disturbance of hearing, in which suspicion of an affection of the central nervous system is awakened by the complexity of symptoms, a minute examination of the sensibility and mobility of both sides of the body, of the state of innervation of the facial, motor oculi, hypoglossal, and trigeminus nerves, of the state of the tendon reflexes, and further, of the fundus oculi, etc., should be undertaken.

From what has been said it is therefore clear that neither the enumerated diagnostic guides, nor the peculiarity of the subjective

symptoms, and of the course of the disturbance of hearing alone, are sufficient for determining the diagnosis of an affection of the nerve. On the other hand, experience shows that only the total impression given by the results of the above methods of examination, which is made from the causative conditions of the disturbance of hearing, the peculiarities of the course and symptoms of the disease, with the etiological factors and results of testing for hearing, makes it possible to determine the diagnosis of an affection of the auditory nerve.

The Diseases of Auditory Nerve Apparatus.

Special Division.

1. *Hyperæmia of the Labyrinth.*

Hyperæmia of the labyrinth is but rarely limited to that section of the ear, being generally combined with congestion of the middle ear and of the cranial cavity.

The greatest hyperæmia of the labyrinth occurs, according to clinical and anatomical observations, in acute purulent inflammation of the middle ear with violent reactive phenomena, especially in the scarlatinal, diphtheritic and typhoid forms. On the dissection of such cases, the congestion is found to be greatest on the external wall of the labyrinth, and in the first winding of the cochlea, and the redness seldom spreads equally over the whole lining membrane of the labyrinth, on the saccules, the semicircular canals, and the lamina spiralis.

As causes of labyrinthine hyperæmia we must mention : the acute exanthemata, typhus, mumps, pneumonia, meningitis, and encephalitis ; tumours of the base of the brain, which impede the exit of blood from the inner ear ; thromboses in the blood channels of the pyramid and jugular vein ; congestion of the head in consequence of a goitre or diseases of the heart and lungs ; angioneurotic congestions in the vessels of the head (caused by the sympathetic nerve) ; intra-cranial affections of the trigeminus and of the medulla oblongata (Baratoux) ; lastly, the use of certain medicinal substances, as quinine, salicylic acid, and especially nitrite of amyl.

Hyperæmia of the labyrinth, according to its intensity and duration, causes temporary disturbances of nutrition or permanent anatomical changes. Among the latter may be reckoned the pigment-exudations in the labyrinth, which are seen so often in chronic

inflammation of the middle ear, the deposition of calcareous salts, and the thickening of the membranous structure of the labyrinth.

The clinical symptoms of hyperæmia of the labyrinth in its more intense forms are subjective noises, giddiness, stupefaction, feeling of fulness in the ears, and dizziness, nausea, vomiting, and unsteadiness of gait. During the continuance of the congestive symptoms, the inner section of the osseous meatus and the vascular leash of the handle of the malleus are often found injected, a state which indicates a general congestion of the ear. (See my *Beleuchtungsbilder des Trommelfells*, 1865, p. 38.) Sometimes this is combined with redness of the face and of the auricle. Without doubt, however, hyperæmia of the inner ear may exist without perceptible injection of the external ear and of the membrana tympani. The hearing-function is either not at all altered, or only temporarily so.

The diagnosis of hyperæmia of the labyrinth may be looked upon as probably correct, when, besides the above subjective symptoms, the objective proof of an excess of blood in the ear is found in the state of the membrana tympani. Hyperæmia of the labyrinth, combined with temporarily recurring congestion of the brain, is distinguished from Menière's disease, with which the symptoms have much similarity, by their rapid subsidence without permanent disturbance of hearing.

More difficult is the differential diagnosis between hyperæmia of the labyrinth and of the brain, as by congestion of the brain, as well as by irritation of the acoustic centres, similar symptoms may be occasioned. It is, therefore, only when there is objective proof of an excess of blood in the ear that the existence of hyperæmia of the labyrinth can be absolutely determined; but the possibility of a simultaneous hyperæmia of the brain participating in giving rise to the combination of symptoms is always also to be borne in mind.

In acute inflammations of the middle ear, simultaneous hyperæmia of the labyrinth may be inferred, when, besides loud subjective noises and deafness, perception for the watch and the acoumeter through the bones of the head is absent, if those phenomena, in spite of inflations and removal of exudation from the tympanic cavity, do not recede immediately, but only later with the decrease of the inflammation of the middle ear.

Hyperæmia of the labyrinth, developed in the course of infectious diseases, cannot be diagnosed. The cause of the disturbance of hearing will be presumed to have been hyperæmia of the labyrinth or of the acoustic centres, possibly with serous saturation and small-celled infiltration of the structures, if during convalescence the normal function of hearing returns.

The *treatment* depends on the cause. If the symptoms occur with congestion of the brain, redness of the face, and increased temperature of the head, but with decided injection of the vessels of the handle of the malleus, an endeavour is made to alleviate the symptoms by derivation to the mastoid process. Sometimes the repetition of an alcoholic embrocation is sufficient (Spirit. aromat., Spirit. formicar., Spirit. sinapis., āā. 30·0. Sig. A teaspoonful to be rubbed in every hour) to lessen the intensity of the noises and the attacks of giddiness. In more obstinate cases the skin over the mastoid process is laid bare by a fly-blister and anointed with tartarated-antimony ointment. Where symptoms of congestion of the brain are absent, after the use of local bleeding I have often observed an increase of the giddiness and noises.

If symptoms of hyperæmia of the labyrinth occur simultaneously with decided signs of congestion of the brain, cold applications to the head (of which the best is Leiter's apparatus), alcoholic embrocations behind the ears, warm foot-baths, purgatives, and in more severe cases local bleeding at the mastoid process, are recommended. As such attacks return at longer or shorter intervals, everything which might occasion a recurrence of the congestion should be guarded against. For such patients a regular mode of living should be prescribed: several hours' exercise in the open air daily, a simple, easily digested diet, and restrictions in the use of alcoholic and carbonated liquors, as well as of tobacco, which should be only very moderately indulged in. When there is an inclination to constipation the use of mild mineral aperient waters is to be recommended (Ofner, Hunyadi Janos, Püllna). Sometimes cold friction is very advantageous, while, on the other hand, affusions to the head and cold douches are decidedly injurious. In angioneurotic forms galvanization of the sympathetic is indicated. When subjective noises predominate, large doses of bromide of potassium are useful, and in great giddiness sulphate of quinine in ½ to 1 gram. dose is of great service.

2. *Anæmia of the Labyrinth.*

Anæmia of the labyrinth is most frequently a part of a general anæmia. The irritation and paralysis of the auditory nerve induced by it occur usually after sudden anæmia, as after child-birth, great loss of blood, severe acute diseases, more rarely in chlorosis and in anæmia caused by chronic diseases. Anæmia of the internal ear is seldom the result of an angioneurosis (vascular spasm) due to the sympathetic, a point upon which we will again touch in speaking of neuroses of the internal ear.

Anæmia localized to the labyrinth may depend upon an impediment to the circulation in the internal auditory artery.

Such impediments are aneurism of the basilar artery, growths projecting from the dura mater or the brain into the internal auditory meatus and compression of the internal auditory artery; further, emboli of the artery, which as Friedreich observed in one case, caused sudden deafness; and lastly, the contraction of the artery caused by atheromatous deposits. It is probable that this condition, under the name of chronic endarteritis, frequently in elderly people extends into the vessels of the labyrinth and there forms the foundation of disturbances of hearing. In a man, aged seventy, who had suffered for a number of years from loud subjective noises combined with moderate deafness, after sudden death caused by rupture of the aorta, it was found that besides extensive chronic endarteritis there were deposits in the basilar artery, from which the condition extended into the internal auditory artery.

Disturbances of hearing arising in the course of great losses of blood are doubtless to be traced to anæmia of the nervous apparatus of the ear. Anæmia of the labyrinth must also have a share in this as well as anæmia of the central source of the auditory nerve. In recent cases the anatomical changes are certainly very insignificant and very transitory. This is confirmed by the necroscopy of a case of deafness, after great loss of blood, observed by Urbantschitsch, in which no anatomical changes were seen either in the brain or in the organ of hearing. Whether in chronic anæmia retrograde changes develop in the auditory nerve, must be shown by further examination.

The symptoms of anæmia of the internal ear after sudden great loss of blood and in the angioneurotic form, are intense noises in the ears and great deafness, accompanied by giddiness, fainting-fits, and vomiting. The whole complex of symptoms is similar to that of sea-sickness, and can be partly traced to simultaneous anæmia of the brain. The phenomena recede more or less quickly with the disappearance of the anæmia. In disturbances of hearing associated with chronic general anæmia, the most prominent symptoms are subjective noises and deafness. These often vary with the varying contents of the bloodvessels of the head, as with congestion after joyful emotions, after the use of alcoholic liquors, and in the recumbent position. Abercromby's case, cited by Lucae, is very interesting; it is that of a man aged thirty, debilitated by an affection of the stomach, who was deaf while sitting or standing, but could hear quite well when he was in a horizontal position.

The treatment of anæmia of the internal ear depends on its cause. The aural symptoms after great loss of blood require no local treatment, as they recede with the disappearance of the general anæmia. In the angioneurotic forms the internal use of bromide of potassium and of quinine, and galvanization of the sympathetic in the throat, are recommended. In chronic general anæmia, besides strengthening diet and residence in Alpine air, the internal use of easily-digested iron remedies, such as mineral waters containing iron, is to be advised, and when circumstances permit of it, a course of iron baths is of good service.

3. *Hæmorrhage into the Labyrinth.*

Small extravasations in the labyrinth occur as a consequence of severe and rapidly-developed hyperæmia most frequently in the course of typhus, variola, scarlet fever, diphtheria (Moos), mumps (Toynbee), nephritis, diabetes (Steinbrügge), leucocythæmia, pernicious anæmia, and upon death from suffocation with or without simultaneous ecchymoses on the mucous membrane of the middle ear. The rupture of the bloodvessels is favoured by atheromatous degeneration of the arteries and by chronic congestive hyperæmia from disease of the heart.

The sites of the ecchymoses are most frequently the lamina spiralis and the external surface of the modiolus, more rarely the saccule of the vestibule and the ampullæ. The extravasated blood may be absorbed, or the blood-colouring matter may remain as granular or flaky pigment.

Larger effusions of blood into the labyrinth result: (1) From fractures of the skull and fissures of the petrous bone. In one case observed by me (*A. f. O.*, vol. ii.), in which a fissure proceeding from the back of the head passed through both petrous bones, total deafness set in with symptoms of the apoplectic form of Menière's disease, in consequence of a great effusion of blood into the cavity of the labyrinth. Lucae observed after fissure of the petrous bone simultaneous effusion of blood into the labyrinth and into the tympanic cavity. (2) From severe concussion of the skull, as is proved by a case of gunshot-fracture of the mastoid process observed by Moos (*A. f. A. u. O.*, vol. ii.), in which without lesion of the labyrinth an effusion of blood was found in it. (3) From extensive carious processes in the temporal bone, particularly from caries and necrosis of the pyramid of the petrous bone (Knapp). In several such cases, in which the capsule of the labyrinth was not injured, I found a few sections of the labyrinth, especially the cochlea,

covered with blackish-brown extravasated blood. In a man who died from otitic meningitis, in whom the capsule of the labyrinth was not eroded, on microscopic examination of the labyrinth I found the superior semicircular canal (Fig. 314, *a*), including the ampulla, partly filled by effused blood (*b*), which surrounded the membranous semicircular canal (*c*), also filled with blood. The vestibule and cochlea were quite free. (4) From diseases of the brain and its membranes, particularly from meningitis. In a case, described by Moos (*Z. f. O.*, vol. ix.), of deafness in the course of a hæmorrhagic pachy-meningitis, there were found on both sides on

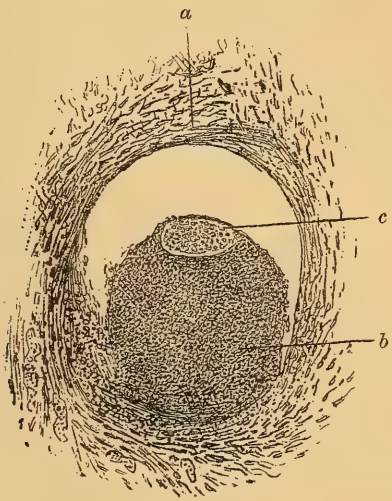

FIG. 314.

a, Section of the osseous semicircular canal; *b*, Extravasated blood; *c*, Section of the membranous semicircular canal.

different parts of the labyrinth, on the utricle, in Rosenthal's canal, between the folds of the lamina spiralis ossea and the zona dentata, smaller and larger hæmorrhagic infiltrations, following the course partly of the veins and partly of the nerve fibres. In another case Moos and Steinbrügge found an extravasation of blood into the cochlea and between the fibres of the auditory nerve, in an individual who had suffered from progressive paralysis for thirteen years. Lucae found in a boy four years old, who had become totally deaf in the course of tubercular basilar meningitis, hæmorrhagic inflammation in the semicircular canals and vestibules of both ears.

Whether labyrinthine hæmorrhage can be caused by pathological changes in the vasomotor centre, clinical and anatomical observations alone can show. In favour of the possibility of such an occurrence are the experiments of

Laborde and Duval (Baratoux, *Pathogénie des Affections de l'Oreille*, Paris, 1881), who, after repeated puncture in certain parts of the medulla oblongata, found an effusion of blood in the cochlea.

The results of labyrinthine hæmorrhage are: absorption, in which, according to Moos, the lymph passages also take part; inflammation, with its termination in suppuration (case of the author's) or in organization of the exudation, or, lastly, in atrophy and degeneration of the epithelium, the connective tissue and the nervous elements, with an abundant formation of granular cells, hyaline corpuscles and pigmentary deposits.

According to Moos, the pigmentary metamorphosis of the extravasated blood in the labyrinth is sometimes extra-cellular, sometimes intra-cellular (through cells containing blood corpuscles). The form and colour of the pigment present the same varieties as in other situations. Since in normal circumstances also, pigment is frequently found in the cochlea in various quantities, it is only great accumulations of pigment in the labyrinth that are of pathological importance (Schwartze).

The Apoplectic Form of Menière's Disease.

The *functional disturbances* to which extravasations of blood into the labyrinth give rise, are but little known on account of the extremely scanty records of post-mortem examinations of cases, the course of which had been minutely observed during life. The first detailed clinical observation with a post-mortem report was published by Menière (*Gaz. Méd. de Paris*, 1861); it concerned a young girl, who, in consequence of exposure to cold at the time of her catamenia, became completely deaf, with symptoms of violent attacks of giddiness and vomiting, and who died on the fifth day afterwards. The necroscopy showed the brain and spinal cord to be unchanged, but the semicircular canals filled by a reddish, plastic exudation, extending somewhat into the vestibule, while the cochlea was normal. The cause of death was not explained by the post-mortem examination.

On the basis of this examination and of a series of other clinical cases, in which with apoplectiform symptoms sudden deafness occurred, accompanied by dizziness, vomiting, and subjective noises, Menière concluded that in these cases we have to deal with a peculiar disease of the labyrinth, in which a combination of symptoms is called forth by an effusion of blood or an acute exudation, as we have seen in animals after injury of the semicircular canals.

In a case observed by me (*Allg. Wien. med. Ztg.*, 1862) of a woman, aged fifty-six years, who, fourteen years previously, became suddenly deaf with

symptoms of apoplectiform Menière's disease with temporary unconsciousness, post-mortem examination showed an osseous growth on the external wall of the labyrinth, the origin of which was probably due to a hæmorrhage of the periosteum at that place. On the left, the osseous growth had quite grown over the fenestra ovalis and become adherent to the stapes-plate; on the right, the anterior part of the fenestra ovalis was free from the osseous mass, the stapes was movable. Power of hearing nil on the left; on the right, speech understood quite close to the ear.

Although, since Menière's publication, apoplectiform deafness, accompanied by characteristic symptoms as described by him, has often been clinically observed and described by aural surgeons, there is still doubt as to the correctness of strictly localizing the above combination of symptoms in the labyrinth.

Moos has emphasized the fact that, in his case of gunshot injury of the mastoid process with total deafness, notwithstanding the hæmorrhage into the periosteum of the internal cavity and in the whole membranous labyrinth, neither subjective noises nor giddiness existed; and these symptoms were also absent in the case, described by Lucae, of hæmorrhagic inflammation of the labyrinth. On the other hand, a case of Oscar Wolf's (*Z. f. O.*, vol. ix.) shows that Menière's combination of symptoms may also be caused by cerebral diseases, the cause of the case in question having been found to be a tumour in the amygdala of the cerebellum and a second swelling in the cerebral cortex.

Although it is not permissible to take the post-mortem appearances of Menière's isolated case as the anatomical basis of apoplectiform deafness observed so frequently, yet, on the other hand, the number of cases of effusion of blood into the labyrinth, without Menière's combination of symptoms, is too small to allow of the assertion that the affection is not principally caused by a bleeding or exudation into the labyrinth. Then it is not the bleeding and exudation alone, but their effect on certain structures of the membranous labyrinth that testify to the occurrence of the phenomena. It can be easily imagined that where, through the effusion, the ampullary nerves are irritated, Menière's symptoms will appear in a decidedly high degree, while they may be quite wanting when the effusion of blood does not act immediately on the vestibular and ampullary nerves.

These considerations may justify the discussion here of this clinically interesting form of disease. While we admit that a series of symptoms, as they appear in Menière's disease, may be due to various changes in the organ of hearing and in the brain, it is necessary to state that we designate by the term Menière's disease only cases of

sudden apoplectiform deafness occurring with the already mentioned symptoms. On the other hand, all disturbances of hearing associated with subjective noises and giddiness should receive the designation of 'Menière's symptoms' or 'Menière's dizziness.' These disturbances of hearing, as we have seen, are also frequently observed in accumulations of cerumen, with vegetations in the external meatus (Hilairet), in affections of the middle ear, in many temporary congestions of the labyrinth and brain after injuries, and in tumours of the brain.

Symptoms.—Menière's disease occurs either with the symptoms of an apoplectiform congestion of the brain or a decided apoplectic attack. It begins either with giddiness, tinnitus, an inclination to vomit or actual vomiting, staggering gait and great deafness, or the patient falls suddenly as from a blow, with loss of consciousness, which returns, however, in a short time with paleness of the face and cold perspiration, also bilateral (seldom unilateral) deafness accompanied by great noises, and on trying to rise there is an inclination to vomit, great giddiness and inability to walk steadily.* Knapp observed, after the attack, temporary dimness of vision, and Moos transitory hemiopia with horizontal line of separation.

The affection usually attacks strong robust individuals with previously normal hearing; but rarely there exist for a longer or shorter period before the attack, tinnitus, slight giddiness, and deafness of a slight degree. Brunner considers great heat as the cause of such an attack in one case. In one of my cases the attack occurred during exposure to the excessive heat of the sun while walking. Gottstein observed three cases of apoplectiform deafness; once combined with tabes, and twice with leucocythæmia.

Examination of the ear shows usually a negative condition of the membrana tympani and of the Eustachian tube, and a minute examination of the nervous system shows no disturbance of function in the region of the cerebral and spinal nerves.

The function of hearing is either completely destroyed or so impaired that only very loud noises in the immediate neighbourhood of the ear can be perceived; perception through the bones of the head for the watch and the acoumeter is always absent. The tuning-fork placed on the vertex is either not heard at all, or very indistinctly so, in bilateral affections, and in unilateral affections it is always

* The loss of consciousness is, according to Bull, posssibly only the effect of mental depression. The oppression and asphyxia, as well as the vomiting, are traced by Moos and McBride to reflex action through the vagus. Huhlings-Jackson accounts for the excessive paleness, the cold perspiration, unconsciousness and vomiting, by the intimate relations of the nuclei of the auditory nerve with those of the vagus and the spinal accessory.

heard only in the normal ear. Three cases of deafness for certain tones, observed by Knapp, are very interesting.

Course.—The course of Menière's disease depends on the intensity of the affection. Of the alarming phenomena at the beginning the unconsciousness and vomiting pass away first, while the giddiness and disturbance of equilibrium, as a rule, diminish after some days, only so far that the patient can walk a little way, either assisted or by the help of a stick. As a rule, the body inclines towards the affected side in walking. The disturbance of equilibrium appears most noticeable in the dark and in walking with closed eyes; even in the slighter degrees the same unsteadiness of gait appears as is observed in high degrees of ataxia. I can confirm from my own experience the observation made by Guye, that in the beginning of the disease the handwriting becomes completely changed like that of a trembling old man. With the decrease of the dizziness and the staggering in the gait, the writing regains gradually its former character. Besides the symptoms mentioned, in the first week of apoplectiform deafness there are mental depression, slowness of thought, and weakness of memory.

In patients in whom no relapse occurs after the first attack, the giddiness and disturbance of equilibrium gradually disappear after some weeks or months. The unsteadiness in the gait may continue for years. The loud ringing and hissing in the ears and head after some time decrease in violence, but may also continue unabated throughout the whole lifetime, even with total deafness. The deafness remains mostly unchanged, and only in a very few cases is there a slight improvement, which remains permanent or undergoes impairment after some months or years. Sometimes the affection ceases after the first attack without relapse, but I have seen cases in which, after several days, or even after weeks or months, new attacks of giddiness and vomiting occurred with increase of the other symptoms.

Diagnosis.—The diagnosis of Menière's disease depends on the already described combination of symptoms, and on the absence of symptoms of paralysis in the area of the other cerebral and spinal nerves. In these cases, therefore, the diagnosis of an affection of the brain is not feasible according to Menière, as in no other organ than that of hearing are symptoms of paralysis observed, which would not be possible if the nuclei of the auditory nerves were affected, since then from the neighbourhood of the centres of other cerebral nerves these would also be involved in the lesion. When some time even before the attack, tinnitus, a feeling of pressure and fulness in the ears, frequent attacks of giddiness and stupefaction, or

a slight degree of deafness were present, the diagnosis without any further evidence ought not to be given as Menière's disease. This must be particularly observed, because, as has already been said, periodical attacks of tinnitus and vomiting, combined with giddiness, are also often met with in diseases of other portions of the ear and of the brain.

From what has been said, therefore, I believe that the diagnosis of Menière's disease can only be made with certainty when it occurs without premonitory symptoms and in a marked degree, and when the surgeon can examine the ear a short time after the attack. If in a previously normal-hearing individual sudden hardness of hearing or deafness sets in with the phenomena of an apoplectic attack, and the gait becomes uncertain and staggering, but without paralysis in the areas of other nerves, and an examination made a short time afterwards shows a normal membrana tympani and a perfectly permeable Eustachian tube, one can with great probability conclude that an affection of the labyrinth is present. While an affection of the tympanic cavity, occurring suddenly with great deafness and the other anomalous phenomena, is characterized by a quick and abundant plastic or muco-purulent exudation, and distinctly perceptible changes on the membrana tympani and in the permeability of the tube will be present. After a lengthened period, however, the diagnosis becomes very difficult, as the products of the acute affection of the tympanic cavity may disappear without leaving any abnormal condition of the membrana tympani or in the tube, and the high degree of functional disturbance may be caused by an intercurrent stiffening of the ossicles.

Prognosis.—The prognosis of Menière's disease is unfavourable in so far as in the cases hitherto communicated complete cure or considerable improvement has been extremely seldom observed. It is only in recent affections, in which the function of hearing is not quite destroyed, that the possibility of improvement is not excluded. In total deafness of months' or years' duration, however, the prognosis is absolutely unfavourable.

Treatment.—At the beginning of the affection treatment is directed to the removal of the troublesome phenomena in the head. Cold bandages on the head, alcoholic embrocations behind the ear, sinapisms on the neck and on the calves of the legs, bathing the skin with lukewarm vinegar-water, and slight derivations to the intestinal canal, have proved the most suitable remedies for the alleviation of the violent symptoms. The diet is at first to be restricted, and it is recommended in the serious forms, in which even slight movements or the stretching of the body suffice to give rise to severe giddiness

and vomiting, to allow the patient to lie on his back with the head moderately high. Loud noises and psychical depression are to be avoided.

Of internal remedies, quinine and iodide of potassium have proved of most service in relieving the giddiness and other head-symptoms. The action of quinine, as recommended by Charcot, must, however, be carefully watched in each case, as sometimes by moderate doses the opposite effect is caused, *i.e.*, great excitement and increased tinnitus. The beneficial action of quinine is more rarely seen in apoplectiform Menière's disease than in the diseases of the ear combined with giddiness and tinnitus. The iodide of potassium should be given in quantities of $\frac{1}{2}$ to 1 gram. daily for at least three or four weeks, always, however, after having first tried quinine for eight or ten days. In recent cases after the cessation of the violent symptoms, about the second or third week subcutaneous injections of a 2 per cent. solution of muriate of pilocarpin (4 to 10 drops daily) are recommended as furthering absorption.

In general there is little to be expected from local treatment. It may be tried after the cessation of the severe symptoms of excitement, and in the second or third week of the affection. We are limited to the injection of 8 to 10 drops of a warm solution of iodide of potassium (0·3 in 20·0), or a 2 per cent. solution of pilocarpine, through the catheter into the tympanic cavity, whence the drug reaches the fluid of the labyrinth partly through the medium of the bloodvessels, partly by diffusion through the membranes of the fenestræ ovalis and rotunda. The injections are continued for three or four weeks every second day, and, in addition, embrocations of the ointment of iodide of potassium or of iodoform on the mastoid process should be used for a longer time. In a case of right-sided apoplectiform Menière's disease, combined with total deafness, in which this treatment was first tried six weeks after the first attack, and continued for four weeks, there was an improvement in the hearing for loud speech to $2\frac{1}{2}$ metres. In a second case, in which treatment commenced ten days after the commencement of the affection, there was an improvement of the hearing, after three weeks' treatment, to $\frac{1}{6}$ metre. Treatment by electricity (see later) is not suitable at the beginning of the affection, as it increases the giddiness and tinnitus, and even after the cessation of these symptoms only weak currents should be used at first. When, after fifteen or twenty sittings, no result is attained, all further attempts should be discontinued. In many cases a course of sulphurous or iodine waters is of some service. Even when no improvement is effected in the hearing, in may cases the treatment exercises a favourable influence on the head-symptoms and on the mind of the patient.

Some remarks on giddiness (*vertigo ab aure læsa*), which so often accompanies diseases of the ear, may be of service here. Notwithstanding the numerous treatises on this, it is still a subject of controversy. While, by many, owing to Flourens's experiment, giddiness is regarded as the result of a pathological irritation of the vestibular and ampullary nerves, others believe that this symptom of cerebral disturbances may be caused by the oscillations of pressure in the subarachnoid cavity, transmitted from the fluid of the labyrinth through the aqueducts, whereby irritation of the auditory, the abducens, and optic nerves, lying at the base of the brain, is brought about. On the irritation of the last-mentioned nerves depends the simultaneous nystagmus and the disturbance of vision.

In fact, Lucae's observations tend to show that the vertigo so often observed in diseases of the ear, in the majority of cases proceeds from the labyrinth. We have seen that, not unfrequently, by moderately strong injections into the auditory meatus, particularly in perforation of the membrana tympani, and, further, sometimes after inflation of air into the middle ear, and on contact of the probe with the free stapes (Lucae, Bonnafont, the author), the most violent attacks of vertigo with nystagmus may be occasioned.* The theory that in such cases, by sudden compression of the labyrinthine fluid, a part of it may be sent through the aqueducts towards the subarachnoid space, and that the attacks of vertigo arise through oscillations of pressure in the cranial cavity, is inadmissible, when it is considered that only a very small quantity of fluid can get through the aqueducts to the arachnoid space, that the intra-cranial pressure itself forms a considerable hindrance to the passage of the labyrinthine fluid into the cranial cavity, and that it is scarcely conceivable that the increase of the large mass of cerebro-spinal fluid by a few drops should occasion such great disturbances of equilibration.

All forms of vertigo and disturbances of equilibration which are combined with an affection of the hearing cannot, therefore, without further symptoms be diagnosed as proceeding from the ear. This conclusion is also arrived at from the observation of cases in which attacks of vertigo and staggering, combined with tinnitus and deafness, may exist for a long time as symptoms of a subsequent affection of the brain.

The attacks of vertigo occurring in aural patients—excluding apoplectiform Menière's disease—appear at irregular intervals, very seldom periodically. The latter form is described by Giovanni Longhi as 'vertigine auditiva miasmatica' in the marshy districts of the Lomellina (Upper Italy). In the intervals, which may last for weeks or months, the patients are either entirely free from all abnormal sensations or have the feeling of giddiness and the unsteadiness of gait in but a slight degree. The attacks return either without any known cause or after bodily exertion, quick turning of the head, bending or rising up suddenly, after emotional excitement, etc. The onset of the vertigo is preceded, as Guye has remarked, by a sense of rotation round the vertical axis, and then from before backwards round the horizontal axis. During the attack, the staggering in the gait increases to such a degree, that

* Roosa (*Dis. of the Ear*) observed attacks of dizziness upon singing higher tones, Jacobson (*A. f. O.*, Bd. xxi.) upon hearing the c^4 tuning-fork.

the patient, when not supported, falls in the direction of the affected side. In slighter degrees the disturbance is particularly marked when the patient tries to walk in the dark or with closed eyes. The subjective noises and the deafness, as a rule, increase during the attack. In the angioneurotic forms and in commencing affections of the brain, the disturbance of hearing may completely disappear after the attack.

Lichtheim's experiments are of great interest as regards the pathology of vertigo ab aure læsa. After introducing the spores of aspergillus into the blood of a young dog he observed an analogous group of symptoms to those produced by injuring the semicircular canals, and found the cause to be the entrance of mycelium into the membranous labyrinth, but without inflammatory symptoms. In animals in which the spores of mucor corymbifer and rhizopodiformis were injected, the labyrinth symptoms were wanting, and no fungus was found in the ear.

As to the treatment of these symptoms, the same holds good as has been said on the treatment of hyperæmia and anæmia of the internal ear and of Menière's disease. In the first place, the cause—when it can be found—must be considered. When the membrana tympani is highly concave, or when there are cicatricial adhesions between the membrana tympani and the inner wall of the tympanic cavity, conditions, therefore, which may indicate an overweighting of the stapes and an increase of the intra-labyrinthine pressure as the cause of the symptoms, we should endeavour to diminish the pressure by rarefying the air in the external meatus (*vide* p. 124). In this way the vertigo is lessened in many cases. Should this manipulation not succeed, or its success not last long enough, then we are justified in trying incision of the tense posterior fold of the membrana tympani or of the tightly-extended cicatrix. In several cases, I have succeeded in lessening the intensity of an attack by such a very simple operation.

With a negative condition of the middle ear, rarefaction of air in the external meatus, in some cases, also renders good service. Therefore, this procedure may always be carefully tried with gradual decrease of pressure. In cases where the dizziness occurs paroxysmally the patient may, after previous instruction, aspirate the air from the meatus by the mouth through a rubber tube provided with an olive tip. Among the internal remedies recommended are quinine in doses of $\frac{1}{2}$ grm. per day (Charcot) for a long time, bromide of potassium and iodide of potassium when there is a suspicion of syphilis. When there is a disturbance of hearing pilocarpine muriate is of service in a 2 per cent. sol., used 3 to 5 drops subcutaneously or 4 to 8 drops internally. Galvanism to the sympathetic is recommended in the angioneurotic form.

4. *Inflammation of the Labyrinth.*

(*Otitis Interna.*)

Primary inflammations of the lining membrane and of the membranous structure of the labyrinth are very rare, and up to the present time have only been observed in some few cases. Of more frequent occurrence are secondary inflammations caused by purulent

inflammations of the middle ear extending to the cavity of the labyrinth. It occurs most frequently with the infectious diseases, especially in scarlatinous diphtheria of the middle ear, where deep destructive changes in the membranous structure are produced by the invasion of the specific excitant of the disease into the labyrinth (Moos). It also occurs with carious and tubercular middle-ear pro-

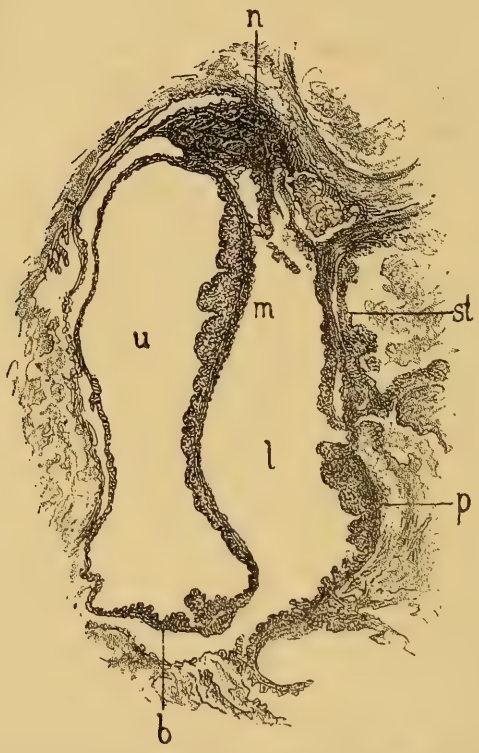

FIG. 315.—FRONTAL SECTION THROUGH THE RIGHT VESTIBULE AND UTRICULUS OF A DEAF WOMAN AGED 93 YEARS, IN WHOM CHOLESTEATOMATOUS MASSES WERE FOUND IN THE EXTERNAL MEATUS AND IN THE TYMPANIC CAVITY. STAPES MOVABLE.

st, Footplate of the stapes; *u*, Utriculus; *l*, Cisterna perilymphatica; *n*, Section of the ramus utriculus; *p*, Promontory with the epithelial growth on its vestibular surface; *m*, Epithelial growth on the inner side of the macul. acust. utriculi; *b*, Prominence of the epithelial layer on the floor of utriculus.

cesses, which frequently extend to the labyrinth. In such cases, in the cavity of the labyrinth, which is laid open by caries and filled with pus, the saccule of the vestibule, the ampullæ, and the semicircular canals, are found thickened, grayish-red, and in parts ecchymosed, the lining membrane of the cochlea, the modiolus, and the lamina spiralis being injected and ecchymosed. In one case,

besides those changes, I found a polypoid growth proceeding from the vestibule, which penetrated into the tympanic cavity through a carious defect of the promontory, and became connected with a polypus springing from the inferior wall of the tympanic cavity.

Secondary purulent inflammations of the labyrinth have been occasionally observed in meningitis and with epidemic cerebro-spinal meningitis. Lucae found in a child which died of meningitis, a hæmorrhagic inflammation of the labyrinth. That inflammatory changes may become quite resolved, is apparent from the clinical observation of cases of typhus, scarlatina, etc., in which deafness occurring during the disease disappears again during convalescence, the function of hearing returning to its normal state.

Of chronic inflammation of the labyrinth, a rare clinical event, the following are the terminations hitherto recognised : Connective-tissue proliferation on the lining membrane of the osseous labyrinth ; hyperostosis and calcareous deposits on the same ; proliferations of reddish, succulent connective-tissue masses filling up the labyrinthine cavity, and the transition of the connective tissue into bone ; thickening of the saccules and ampullæ ; deposition of pigment, cholestearine and calcareous salts in the latter ; excessive epithelial growth on the inner side of the saccules and on the scalæ of the cochlea (Politzer), (Fig. 315) ; atrophy of the membranous labyrinth ; and fatty degeneration and disappearance of Corti's organ. That an exudate may be produced by a hindered flow of blood from the labyrinth, is shown by a case lately seen by me (man, aged 63 years) of sarcoma of the dura mater which completely compressed the nerves and vessels in the internal meatus. On the inner side of the saccule of the vestibule, in the cochlea, and in the semicircular canals there was a plastic fibrinous layer $\frac{1}{3}$ mm. thick. In several post-mortems performed lately, I found the pathological changes (exudate, connective tissue and osseous new growth) most frequently in the scala tymp. of the cochlea. According to Steinbrügge, the lowest coil of the cochlea is the portion of the labyrinth most intensely diseased.

Clinical observations on primary inflammations of the labyrinth with records of the post-mortem appearances are very scarce.

Voltolini first directed the attention of aurists to an ear-affection occurring in children, which he terms acute inflammation of the labyrinth. The affection comes on very suddenly in previously quite healthy individuals, with fever, great congestion of the face, and vomiting, followed by unconsciousness, delirium, and convulsions. These symptoms completely disappear after some days, but total deafness and staggering in the gait remain for a long time. The phenomena during the acme of the affection are very similar to an

acute meningeal disease. While, however, a meningitis ending in deafness terminates as a rule after several weeks, the serious symptoms of the disease in question disappear in a short time, so that very often in four or five days all the functions are normal, with the exception of the deafness and the staggering gait. The difference in the duration of the groups of symptoms is the basis of Voltolini's support of the diagnosis of a primary inflammation of the labyrinth. He has not been successful in confirming his assertions by pathological investigations.

Voltolini's conclusion, that an intra-cranial affection, which leads in a few days to total paralysis of the auditory nerve, must necessarily cause disturbances in the course of other cerebral nerves, that, therefore, a central cause of the deafness in these cases must be excluded, does not appear sufficiently sound to determine the diagnosis of an acute inflammation of the labyrinth. As to the assertion that in a series of Voltolini's cases a meningeal affection lay at the foundation of the group of symptoms, confirmation is found in Gottstein's observation, that in the course of epidemics of meningitis abortive forms occur in which the initial symptoms recede after a few days, either with complete recovery or leaving deafness as a sequel. The latter may be caused either by simultaneous purulent inflammation of the labyrinth transmitted from the cranial cavity, or by an affection of the stem or nucleus of the auditory nerve. The absence of simultaneous disturbances in the areas of other cerebral nerves in these cases is explained by the already mentioned extreme susceptibility of the auditory nerve, which may be permanently altered by a very slight injury, to which the other cerebral nerves could offer sufficient resistance.

However, the occurrence of a primary inflammation of the labyrinth with the group of symptoms described in children is not easily proved. The following case, minutely examined by me, is the first to anatomically show this form of inflammation, and the results of recent examination have shown that labyrinth inflammation resulting in the new growth of bone occurs more frequently than was formerly supposed.

The case was that of a boy who, according to his father, became deaf at the age of two and a half years, during a feverish complaint which lasted fourteen days. The most prominent symptoms during the illness were great restlessness, repeated eclamptic attacks, and a discharge from both ears, which is said to have continued till the age of six or seven. The boy, who was able to get up after fourteen days, showed no staggering in his walk, and later, after his entrance into the Vienna Institute for the Deaf and Dumb, no disturbance of co-ordination was observed in him.

He died at the age of 13 from acute peritonitis. The necroscopy gave the following result: Both membrana tympani, as well as the mucous membrane of the tympanic cavities, were normal. The malleus and the incus were freely movable. The stapes, on the other hand, was fixed and immovable on both sides. The niche of the fenestra rotunda was indicated by a small fossa, the base of which was formed by a solid osseous mass.

Examination of the decalcified labyrinth gave the following results (Fig. 316): The capsule of the cochlea was intact and demarcated from the overlying portion of the petrous bone. The coils of the cochlea could be plainly distinguished throughout. The cavity of the cochlea (*b*) was entirely filled with new-formed osseous tissue, which bore the character of periosteal bone. The auditory nerve (*c*) entered with its normally arranged medullated

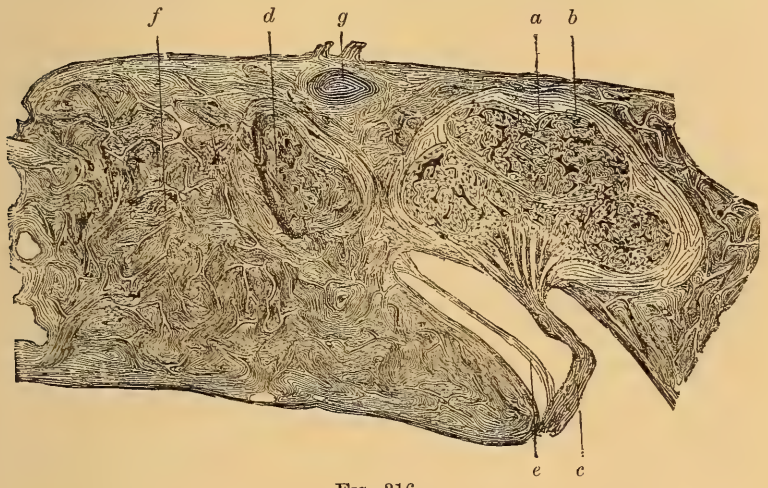

Fig. 316.

and non-fatty nerve-bundles into the modiolus, but its fibres continued only a short distance into the new-formed osseous mass.

The vestibule (*d*) was narrowed by the hyperplastic process to a small angular space lined with roundish epithelial cells.

The semicircular canals were completely absent. The parts could be recognised only with a high magnifying power, owing to the peculiar structure of the new-formed osseous tissue completely filling up the canals.

From the anatomical conditions there can be no doubt that the original process consisted of a purulent inflammation of the labyrinth, through which proliferation of its connective tissue was set up, and had led to the formation of periosteal bone. Similar changes are sometimes found as the result of chronic suppurations of the middle ear in the tympanic cavity, more frequently, however, in the mastoid process, where the pneumatic cell-spaces are so completely filled up by ossifying connective tissue that the whole process

becomes transformed into a solid osseous mass. Whether in these cases a perforation of the pus from the labyrinth into the tympanic cavity followed, or the process originally began as a panotitis, cannot be determined from the post-mortem examination.

Partial and total ossification of the labyrinth, as the result of an inflammation, have been observed and reported several times lately. Moos (*Z. f. O.*, Bd. xii.) found in a girl, who was said to have become deaf after meningitis, an osseous growth from the inner wall in the lower coil of the cochlea, by which both scalæ were narrowed. Kundrat demonstrated, at the meeting of the Ges. deutsches Ærge, a total osseous obliteration of the labyrinth in a man aged 30 years, which was said to come after an injury to the skull. In a series of microscopical preparations, which came to me as the bequest of my deceased friend, Professor Burckhardt-Merian, were some from a deaf and dumb person, aged 36, in whom the cause of the deafness could not be told. The greatest part of the basal coil of the cochlea was completely ossified, while the middle and upper coils were free. The spinal ganglion still contained a number of ganglion cells. Gradenigo demonstrated at the meeting of the combined South German and Swiss Aurists, in Vienna, April 11, 1887, the histological conditions of a deaf and dumb person in whom there was nearly a complete ossification of the labyrinth. A similar condition was found by Larsen and Mygind (*A. f. O.*, Bd. xxx.) in a man who became deaf and dumb from cerebro-spinal meningitis, and died at the age of 27 from tuberculosis. That ossification of the labyrinth is not so rare is shown by the histological examination of several cases which were deaf or deaf and dumb, and where, besides anchylosis of the stapes, there was partial ossification of the labyrinth. It should be mentioned that in the cases published the partial ossification was most developed in the basal coil and became gradually less toward the cupola.

Panotitis.

This name is applied to that form of disease of the ear in which the middle ear and the labyrinth are either seized simultaneously by the inflammation or the one very quickly after the other.

It occurs chiefly in children, either as an idiopathic affection or in the course of scarlatinal diphtheritis, and then always on both sides, and leading after a short duration to total deafness.

The purulent infiltration of the membranous labyrinth occurring with purulent middle-ear inflammation, as seen by Moos in variola vera, is classed by me with the form of inflammation of the ear called panotitis.

The idiopathic form begins with high fever, to which are often added eclamptic attacks with or without unconsciousness. Its duration varies from a few hours to several days. After the return of consciousness the individual affected is totally deaf; and then

after a few days, rarely before the return of consciousness, a discharge from both ears sets in with perforation of the membrana tympani. In all cases the affection has been combined with staggering in the gait.

This form of disease may be illustrated by the description of a few cases.

In a child, aged 6, the affection commenced with high fever, on which there supervened, after some hours, a convulsive attack with unconsciousness. Sudden deafness set in after thirty-six hours. On the tenth day, after the fever had abated, a bilateral ear-discharge commenced, which ceased after fourteen days. Four days later an abscess formed behind the right ear, which was opened and healed up in a short time. Five months after the commencement of the affection, the result of examination on the right side was: dry perforation behind the handle of the malleus; on the left side at the same place there was a cicatrix on the membrana tympani adherent to the inner wall of the tympanic cavity. The function of hearing was completely destroyed for every kind of tone or noise.

In a boy 3 years old there had occurred, three weeks before the first examination, high fever and headache without affecting the consciousness. After two days with the abatement of the fever there commenced a slight bilateral ear-discharge. The parents at the same time observed that the child had become totally deaf, and that he staggered so much in walking that after a few steps he fell. Result of objective examination: Perforation of both membranes; total deafness without a trace of perception of sound.

A girl, aged 3 years, became suddenly very feverish during the night of the 15th April, 1879. Towards morning unconsciousness set in, which lasted for fourteen days, with slight convulsive attacks and cervical contraction. After return to consciousness she was totally deaf, and staggered in walking. In the eleventh week a discharge set in from the left ear, which ceased three weeks before the first examination on 5th June 1880, which showed on the right side: highly concave inflamed membrana tympani; on the left, dry perforation in the anterior inferior quadrant; and total deafness, as in the two former cases.

There can be no doubt that in these cases the middle ear and the labyrinth had been attacked by inflammation. Whether the process appeared simultaneously in both sections, or sooner in the one than in the other, cannot be determined, as their commencement was not observed. The late appearance of the ear-discharge (eleven weeks after the beginning of the affection in the third case) would seem to indicate that the suppuration proceeded from the labyrinth and was transmitted to the middle ear after bursting through the fenestra rotunda or ovalis.

The *prognosis* of this form of inflammation is unfavourable.

Treatment.—The internal use of iodide of potassium, long-continued embrocation with iodine and iodoform ointments behind the ear,

subcutaneous injections of a 2 per cent. solution of pilocarpine (2 to 4 drops through 20 to 30 days), the water and bath cures at the iodine baths of Hall, are almost always without effect.

To the diphtheritic form of panotitis belong those cases in which total deafness sets in in the course of scarlatinal diphtheritis. The deafness is either caused by a purulent inflammation of the labyrinth, or, as Moos indicated some years ago, by a coincident small-celled infiltration of the membranous labyrinth, which causes disorganization of the termination of the auditory nerve.

An interesting case of diphtheritic panotitis was a girl, 8 years of age, who became ill five months previously with scarlatinal diphtheritis. On the eighth day a bilateral ear-discharge set in, and on the same day also total deafness. Her walk was unsteady only during the first week after cessation of the diphtheritis and no longer. Objective result: On the right, perforation of the membrana tympani and polypoid growths in the tympanic cavity; on the left, extensive destruction of the membrana tympani; on both sides profuse blenorrhœa. Function of hearing quite destroyed for every kind of sound and noise.

The *prognosis* of diphtheritic panotitis is not absolutely unfavourable, as shown by the cases seen by Moos and O. Wolf. In some cases pilocarpine mur., which I first recommended for labyrinth exudation, has proved of benefit even here. In a case observed by Moos of total deafness in a girl 7 years old, following scarlatino-diphtheritic middle-ear inflammation, by the injection of a weak pilocarpine solution, continued for several months, a hearing-distance of $3\frac{1}{2}$ m. for loud speech was attained in the left ear. Oscar Wolf (*Corresp. Bl. f. Schweiz. Aerzte.*, 1883) reported a brilliant result from the pilocarpine treatment in a girl 6 years old, who, 10 days after becoming sick with scarlatinous diphtheria, became completely deaf. After its use for 8 to 10 days loud speech could be heard near the ear, and in the twentieth week whispering could be heard at 1 m. distance.

5. *Leucocythæmic Deafness.*

During the course of leucocythæmia exudative and hæmorrhagic processes may occur in the ear, as in all other organs (liver, kidneys, lymph glands, serous and mucous membranes), the seat of which is sometimes principally in the middle ear, sometimes in the labyrinth. The frequency of the coincidence of a disturbance of hearing with leucocythæmia is not as great as that of leucocythæmic retinitis, but is estimated by Vidal and Isambert at about 10 per cent. of all cases. In the report of these authors the clinical analysis of the leucocy-

thæmic disturbance of hearing and the anatomical conditions underlying it, are wanting. The first case of leucocythæmic deafness observed clinically and examined pathologically was reported by me at the Otolog. Congr. in Basel in 1885.

A man, 32 years old, with a severe type of splenic, glandular and myelogenic leucocythæmia, had otorrhœa in his left ear for a long time while a child. He suddenly became deaf in both ears over-night about a year before his death. The objective examination of the ear two months before his death showed: dulness and retraction of the right and almost complete destruction of the left membrana tympani, with complete bilateral paralysis of the auditory

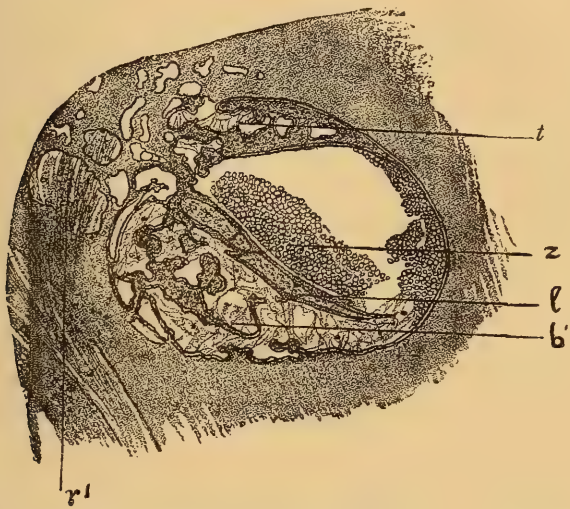

FIG. 317.—SECTION OF THE BASAL COIL OF COCHLEA FROM A DEAF MAN, AGED 32, WHO DIED OF LEUCOCYTHÆMIA.

l, Lamina spiralis; *b'*, Connective tissue and osseous growth in the scala vestibuli; *z*, Leucocythæmic plaques in the scala tymp.; *t*, Osseous growth on the median wall of the scala tymp.; *r'*, Atrophic ganglion layer in Rosenthal's canal.

nerve. Diagnosis of leucocythæmic exudate into the labyrinth was made. Upon dissection was found, besides the usual appearance of leucocythæmia, right: strong retraction of the membrana tympani, great thickening of the middle-ear mucous membrane and the covering of the ossicular articulations; left: total defect of the membrana tympani, hammer, and incus; swelling and thickening of the tympanic mucous membrane, especially in the region of the fenestra ovalis, with slight rigidity of the stapes.

The histological examination of the internal ear showed a complete affirmation of the clinical diagnosis. In cross sections of the cochlea (Fig. 317) the scala tympani was filled with an irregularly formed osseous framework (*b'*), which was attached to the osseous wall of cochlea, the spaces of which contained newly-formed connective tissue in different stages of development. In the scala vestibuli, besides the large osseous growth (*t*), there were leuco-

cythæmic plaques (*z*) lying upon the median wall of the cochlea and upon the spiral plate (*l*). The membranous semicircular canals were surrounded by young cells and a vascular connective tissue which entirely filled the space between the membranous and osseous structures. The inner membranous canal was filled with leucocythæmic lymph cells. Similar lymph conglomerations were found everywhere in the vestibule of the right ear, and also in the left labryinth, where only small amounts of new connective-tissue growths were present.

Clinical observations without post-mortem examination of cases occurring with leucocythæmia have also been made by Perrin, Friedländer, Pepper, Gottstein (2 cases), and Blau, yet in the cases of the three first mentioned no objective examination of the ear was made. From the observations made it is shown that leucocythæmic ear disease, where it affects the inner ear, commences with complete deafness, dizziness, and occasionally also with facial paralysis (Gellé). According to Gradenigo, it is preceded by some previous ear lesion (otitis media), which favours the occurrence of the specific leucocythæmic exudative process. Where, during the course of the disease, the hearing improves (Blau), or, as Pepper observed, becomes quite normal, the changes in the labyrinth must be very slight. In the severe forms leucocythæmic exudation into the labyrinth and lymphatic infiltration of the membranous labyrinth occurs. Through reactive processes from the periosteum and the connective-tissue apparatus of the inner ear, secondary chronic inflammation occurs, which may fill the labyrinth with connective tissue and lead to its partial ossification.

An interesting case of leucocythæmic deafness which did not originate in the labyrinth, but was more of a specific affection of the middle ear, was described by Gradenigo (*A. f. O.*, Bd. xxiii.). A patient with severe and advanced leucocythæmic cachexia and severe nasal hæmorrhage was suddenly seized with marked deafness of both ears which partly passed away. The necroscopy showed a quite negative condition of the labyrinth, but an extensive growth of the tympanic mucous membrane with parenchymatous hæmorrhages and the remainder of blood extravasations.

In an individual 25 years of age, observed by Steinbrügge (*Z. f. O.*, Bd. xvi.), who had leucocythæmia, sudden deafness occurred fourteen days before he died, and the post-mortem examination showed: old connective-tissue adhesions in the niches of the fenestræ; in the cochlea were large blood extravasations which covered the organ of Corti, and also free extravasation into the sacculus. The otherwise normal membranous semicircular canals were surrounded by newly-formed osseous tissue, which Steinbrügge did not consider as due to the leucocythæmia, but to a former syphilis.

In a case (man, aged 34) carefully watched by Lanois (Guggenheim's *Annales mal. de l'oreille*, etc., 1892), during a long course of leucocythæmia complete deafness with Menière's symptoms developed eight months before

the fatal termination. The histological examination gave blood extravasation into the vestibule and semicircular canals, partially organized masses of fibrin, new connective-tissue growth in the osseous semicircular canals, and cell-infiltration in the scala vestibuli of the first coil of the cochlea.

To these observations may be added the recent one by Wagenhäuser of the condition of the labyrinth in a woman, aged 35, with splenic leucocythæmia. There were extravasations in the cochlea and vestibule, and new connective-tissue growth, with occasional osseous formation from the periosteum of the ampullæ and semicircular canals (*A. f. O.*, Bd. xxxiv.).

6. *The Syphilitic Diseases of the Internal Ear.*

Syphilitic diseases of the labyrinth rarely develop simultaneously with the secondary cutaneous or throat affection (once within my experience on the seventh day after the primary infection). It occurs more frequently as a late form of syphilis, generally at the end of the second or beginning of third stage, or it may appear months or years after the primary affection, either with a new outbreak of syphilitic symptoms (in one of my cases with gumma on the head after twenty-one years), or when no sign of syphilis is observable on the body. Syphilis of the labyrinth may also occur as the only symptom of an as yet unexhausted general syphilis, either localized in the inner ear or accompanied by catarrhal or purulent middle-ear inflammation. The syphilitic affection may also be added to a middle-ear inflammation which existed before the infection.

The anatomical changes in syphilis of the labyrinth are but little known. Whether in recent cases there is a plastic exudation in the labyrinth similar to that in syphilitic iritis has not been proved. Little is known of the inveterate forms. In a syphilitic individual, aged 37, in whom intense subjective noises, attacks of vertigo and headache, suddenly commenced without considerable disturbance of hearing, considerable deafness having set in only shortly before death, which occurred a year and a half afterwards, Moos (*Virch. Arch.*, vol. lxix., p. 313) found at the autopsy: condensation of the periosteum of the vestibule, the footplate of the stapes raised and immovable, the connective tissue between the membranous and the osseous labyrinth infiltrated with small cells and hyperplastic, Corti's arch and cells especially considerably infiltrated, the zona pectinata and the periosteum of the lamina spiralis ossea less strongly infiltrated; the ampullæ and the membranous semicircular canals were alike greatly infiltrated, the auditory nerve normal. Moos and Steinbrügge (*Z. f. O.*, Bd. xiv.) found in a case of deafness with tertiary syphilis: enlargement of the osseous spaces in the temporal bone, and the labyrinth capsule was partly filled with blood and partly with fibrous tissue infiltrated with small cells, which was undoubtedly connected with the periosteum of the labyrinth wall in places. There were also extravasations of blood between the fibres of the auditory nerve,

and into the cochlea, and degeneration of the ganglionic layer in Rosenthal's canal. Recent investigations show, without a doubt, that in the old cases an osseous growth from the periosteum takes place owing to the chronic inflammation of the lining of the labyrinth.

A case observed by me concerned a man, 50 years of age, who had been deaf for ten years in consequence of a syphilitic affection. On the right membrana tympani, two broad, ligament-like stripes proceeded downwards at an acute angle from the inferior end of the handle; perception through the bones of the head was absent. Death resulted from phthisis pulmonalis. Post-mortem appearances: The ligament-like stripes on the membrana tympani were condensations and elevations of the epidermis, the mucous membrane of the tympanic cavity and the ossicles were normal on both sides. On decalcified sections of the cochlea the ganglion cells in Rosenthal's canal were morbidly changed. The cells were partly round and granular, without a distinct nucleus, partly oval and angular bodies, in some of which only was a nucleus observed (atrophy and degeneration of the ganglion cells in the ganglion spirale). The modiolus exhibited in parts a reticular structure. On the spiral membrane, in the vestibule, and on the semicircular canals, no changes were visible which could be termed pathological.

Atrophy and degeneration of the ganglion cells in Rosenthal's canal was found by Moos and Steinbrügge, as well as atrophy of the auditory nerve-fibres between the layers of the lamina spiralis ossea, especially in the region of the first coil of the cochlea.

The changes in the bloodvessels in syphilis, described by Heubner, have only been seen, so far, in one case by Baratoux, and more recently by Kirchner. They found a typical endarteritis luetica in the bloodvessels of the tympanic mucous membrane, lens-shaped osseous accretions from the periosteum on the promontory, and the formation of cavities in the walls of the labyrinth, which were due to obliteration of the vessels. Observations as to the anatomical changes in the nuclei of the auditory nerve have not yet been made.

Symptoms.—The most prominent subjective symptom is tinnitus, which in many cases appears suddenly and is very pronounced. Subjective noises are seldom entirely wanting. Double hearing (Roosa) is only observed in rare cases. Pain in the interior of the ear, with tinnitus and deafness, I observed in only one case, without objectively perceptible inflammatory phenomena on the membrana tympani. On the other hand, attacks of vertigo, with disturbances of equilibration, are frequent, and the ear-affection is often prefaced by these symptoms.

The objective examination reveals either a normal state of the membrana tympani, or changes which proceed from an existent or exhausted affection of the middle ear. Twice I have found peculiar sharply defined whitish patches on the membrana tympani. The Eustachian tube is normally pervious or swollen, and contracted by a simultaneous affection of the naso-pharynx, or, in ozæna, blocked

by crusts. I have several times found the lymphatic glands over the mastoid process greatly swollen.

The deafness is in most cases complete. The affection is seldom unilateral; in bilateral affections the one ear is usually more affected than the other. The hearing-distance for the watch and the acoumeter is very small even in slight cases; in severe cases it is *nil*. Inflating the middle ear has very slight influence on the hearing-distance. Perception through the bones of the head is lessened or quite absent; in unilateral affections the tuning-fork is only perceived in the normal or better-hearing ear; in bilateral total deafness perception for the tuning-fork is quite wanting. When the sounds are conducted through the air high notes are not so well heard as low ones; Rinne's experiment frequently turns out positive in labyrinthine syphilis (Rohrer).

Course and Terminations.—The course of syphilitic affections of the labyrinth, according to the unanimous observations of v. Tröltsch, Roosa, Schwartze, Knapp, Moos, Buck, and myself, is characterized by the rapid development of disturbance of hearing. I have seen cases in which deafness was almost complete on the third day after the commencement of the disturbance of hearing. The deafness not uncommonly, however, comes on gradually, to remain the longer stationary, till after weeks or months it becomes suddenly worse. That even slight concussions of the head are sufficient to bring about an aggravation (v. Tröltsch, Urbantschitsch, Gruber), I can confirm from my own observation. Oscillations in the hearing-distance are rare. When improvement or recovery results, it does not happen all at once, but gradually. In progressive improvement the perception through the bones of the head also returns. In one of my cases the perception for the acoumeter from the ear towards the forehead increased gradually.

Diagnosis.—The diagnosis can be given with certainty as labyrinthine syphilis, when the disturbance of hearing has rapidly developed with the symptoms detailed, and when perception for sound through the bones of the head is wanting, and at the same time symptoms of secondary syphilis are present on other parts of the body, or in the eye, or when there can be no doubt of its former presence from the history. In young people especially, the rapid development of the disturbance of hearing, with the absence of objective symptoms of an affection of the middle ear, is sufficient to raise the suspicion of labyrinthine syphilis. In several such cases, in which the primary infection was denied, I was able on minute examination to prove general syphilis to be the foundation of the disturbance of hearing. Even in those cases in which an affection

of the middle ear exists at the same time, from the manner of development of the disturbance of hearing, and the absence of perception through the bones of the head, in connection with an existing or exhausted syphilis, a specific affection of the labyrinth may with probability be inferred. The diagnosis becomes more difficult when the disturbance of hearing develops gradually and not till some years after the termination of the syphilis, as in such cases the possibility of the development of an adhesive process in the neighbourhood of the stapes, quite independent of an exhausted syphilis, cannot be excluded. In children whose answers in testing are often contradictory, and therefore worthless, the objective symptoms are the only sure points for diagnosis.

Those forms of syphilitic affection of the labyrinth are to be regarded as hereditary which develop in childhood with great or total deafness, the foundation of which has hitherto been referred to scrofula. According to Hutchinson and Jackson the ears are affected in 10 per cent. of all children with hereditary syphilis, and according to Hermet and Baratoux in one-third of all the cases. The latter found in syphilitic new-born children, who died, suppurative middle-ear inflammation, thickening of the membrana tympani and adhesion of it to the promontory; in the labyrinth hyperæmia and hæmorrhages, pus in the vestibule and destruction of Corti's organ. The anatomical changes in the later stages are not known. Hereditary syphilis of the labyrinth is frequently combined with middle-ear catarrh, suppurative middle-ear inflammation (Baratoux) or adhesive processes in the middle ear combined with great opacity of the cornea from a chronic keratitis parenchymatosa, the syphilitic nature of which has been shown (Horner, Knapp). According to Hutchinson, the disease is peculiar from the accompanying characteristic changes in the teeth (Hutchinson's teeth).

Recently Kipp has collected a series of cases in which disturbances of hearing caused by hereditary syphilis were combined with parenchymatous keratitis, and one case with syphilitic iritis. The symptoms given by Kipp were sudden deafness, vertigo, disturbances of equilibrium, subjective noises, naso-pharyngeal catarrh, and sometimes also catarrh of the middle ear. The statement that slight changes may be present on the membrana tympani, I cannot from my own observations confirm. According to Hinton the disturbance of hearing frequently occurs first at puberty.

Prognosis.—The *prognosis* is in most cases unfavourable, generally, however, more favourable in recent than in old cases. The degree of deafness does not always determine the amount of restoration of the normal function of hearing, as sometimes after total deafness

recovery may take place, while slighter forms, notwithstanding energetic anti-syphilitic treatment, often remain incurable and may even become worse through time. Unfavourable prognostic circumstances are: advanced age, anæmia, marasmus, incurable general syphilis, simultaneous adhesive processes in the middle ear, and stricture of the Eustachian tube. The above-mentioned hereditary forms, combined with opacity of the cornea, are also unfavourable.

Treatment.—The treatment of labyrinthine syphilis is the same as that of general syphilis. In its slighter degrees, the iodide cure is sometimes sufficient. In the majority of cases, however, it is insufficient and less effective than mercurial inunction. In recent cases I have had several favourable results from the subcutaneous injection of a 2 per cent. solution of muriate of pilocarpin in increasing doses of from 4 to 12 drops. This treatment should be first used, and iodine or mercury resorted to, should the pilocarpin injections have no marked effect after eight to fourteen days.

General treatment may besides be supplemented by injections of a solution of iodide of potassium into the tympanic cavity, and by embrocations of iodoform, iodol or mercurial ointments behind the ear. In cases where a marked improvement of the hearing is not attained, either by local or by general treatment, the use of a course of iodine or sulphur baths is to be recommended.

The rachitic changes in the labyrinth are but little known, and we only possess one exact observation by Moos and Steinbrügge (*Z. f. O.*, xi.), which will be briefly related here. At the necroscopy of a deaf and dumb idiot affected with general hyperostosis of the cranium, there were found hyperostoses on the inner wall of the tympanic cavity, great contraction of the internal auditory meatuses, ossification of the annular ligament, and a portion of tissue in the right cochlear capsule near the fovea hemispherica, consisting of cartilaginous cells and fibrous cones slightly coated with calcareous deposit, changes which are to be regarded as rachitic, according to Virchow. At the same time there were found congenital malformations, bilateral imperfect ossification of the Fallopian canal; on the left side absence of the footplate of the stapes, and in its place an osseous mass, which passed directly into the osseous substance of the labyrinthine capsule. On the right, instead of the crura of the stapes, slipper-shaped cones were seen, ossified only at their external periphery, between which was lodged a highly cellular connective and adipose tissue.

7. *Diseases of the Auditory Nerve.*

Clinical observations on diseases of the stem of the auditory nerve and its expansion are so rare that we must limit ourselves to the enumeration of its hitherto recognised anatomical changes.

Hyperæmia of the neurilemma of the auditory nerve is very

often present in congestion of the meninges, particularly in meningitis, encephalitis, in aneurism of the basilar artery, but especially in engorgements of the vessels of the brain.

Ecchymosis on the stem of the auditory nerve has been observed in fractures of the petrous bone, in scurvy, and once in fatty degeneration of Corti's organ, and with syphilis of the ear (Moos).

Purulent inflammation and infiltration of the auditory nerve were observed in purulent basilar meningitis, in epidemic cerebro-spinal meningitis, and in suppuration spreading by caries and necrosis of the petrous bone or by traumatic fracture of the latter.

Hypertrophy of the stem of the auditory nerve, caused by infiltration and proliferation of the neurilemma, is very rare. I have found it in extensive caries of the petrous bone simultaneously with nodose thickenings on the facial nerve.

Atrophy of the auditory nerve is much more frequently met with. It develops either in consequence of contraction of the basilar and internal auditory arteries, in aneurism of the basilar artery (Griesinger), or as a result of apoplectic and inflammatory processes on the floor of the fourth ventricle, and in the neighbourhood of the nucleus and roots of the auditory nerve; lastly, in diseases of the cerebellum and in hydrocephalus internus, and rarely secondary to long-continued deafness from anchylosis of the ossicles.

A case observed by me affected a young man, who, with symptoms of hydrocephalus, in the course of several years became paralyzed in all his extremities; he became quite blind and deaf, and died with symptoms of marasmus. The necroscopy revealed a tumour (osteosarcoma) originating in the sella turcica, hydrocephalus, dilatation of the ventricles, atrophy of the cerebral substance, great thinness of the cranial bones, the origin of the optic nerve flattened, no change, however, in the eye itself; the internal auditory meatus was enlarged to three times its size; the auditory nerve, together with the facial, made up a thin, thread-like nerve-bundle; the membrana tympani was thickened, and attached by firm connective-tissue adhesions to the inner wall of the tympanic cavity; the ossicles moved with difficulty; in the cochlea there were abundant depositions of amorphous pigment.

Disappearance of the auditory nerve, as atrophy from pressure till the nerve-stem is completely separated, is observed in tumours of the brain and tumours on the base of the skull, which either press on the point of emergence of the auditory nerve or grow into the internal auditory meatus.

In a case described by Böttcher (*A. f. A. u. O.*, ii.), of a tumour of the brain (fibrosarcoma) which penetrated into the internal auditory meatus as far as the modiolus, the auditory and the facial nerves were atrophied to a thin cord, the nerve-bundle in the modiolus and in the lamina spiralis absent, and

the nerve-canals were filled up by connective tissue; and besides, Böttcher found atrophy of the stratum cellulosum and of the external and internal ciliated cells.

In a case of sarcoma of the dura mater, lately examined by me, which extended as far as the fundus of the internal meatus, the auditory nerve was atrophied to a thin, thread-like cord. Besides total deafness there was dizziness and a staggering gait. Virchow, Gellé, and Roudot describe cases of compression of the auditory nerve from syphilitic gummata, with deafness of affected side. Cases of this kind are occasionally combined with paralysis of the facial nerve, dizziness, tinnitus, nocturnal headache, and choked disc. In a case of Urbantschitsch's in which there was severe trigeminal neuralgia beside the deafness, the examination showed a new connective-tissue growth from the neurilemma of the trigeminus, by which the auditory nerve was flattened in the internal meatus.

Schwartze (*Pathol. Anat. d. Ohres*) describes a tubercular growth the size of a pigeon's egg, growing from the dura, which compressed the auditory nerve. Gomperz, a fibrosarcoma of the meninges, through the growth of which the right auditory and facial nerves were enormously stretched and atrophied.

Pressure-atrophy of the nerve is further caused by excessive stricture of the internal auditory meatus. This is developed especially in extensive osseous deposits on the tabula vitrea of the internal surface of the skull, and in consequence of periostitis ossificans syphilitica (Zeissl).

It is known that disturbances in the region of the auditory nerve occur in affections of the spinal cord, and particularly in tabes. The clinical examination of 53 cases of tabes by Morpurgo and Marina (*A. f. O.*, Bd. xxx.) gave the surprising fact that tabetic affections of the ear may occur at any stage of the disease. Of 53 cases of tabes only 10 had normal hearing; in 35 with difficulty in hearing, Rinne was positive, of which 26 cases appeared normal upon objective examination; of 35 cases examined by Weber's test, in 24 lateralization did not occur in the more affected ear; only in 3 cases was there improvement in hearing after using the air-douche. Anatomically there are only few characteristic appearances, and the source of the tabetic disturbances of hearing has not been sufficiently investigated. While Erb (Ziemssen's *Handbuch*, p. 142), in some cases of tabes, found definite atrophy of the auditory nerve, and Wernicke gray degeneration of the auditory nerve, to be the cause of the progressive deafness in tabes and in disseminated sclerosis, Lucae (*A. f. O.*, ii.) could find no changes in the auditory nerve in gray degeneration of the spinal cord. On the other hand, Habermann found in a tabetic patient aged 52 years, who had been deaf 13 years, great atrophy of the nerve and ganglion cells in the cochlea, vestibule, and ampullæ, also connective-tissue degeneration of the ramus cochleæ and vestibuli, with a large

deposit of amyloid bodies, and the central extension of the auditory nerve was atrophied as far as its nucleus, the latter of which, however, appeared intact.

Besides atrophy of the auditory nerve caused by affections of the central nervous system, atrophy may also supervene on peripheral changes in its terminal expansion in the labyrinth. Among such changes are the purulent inflammation which follows carious perforation of the labyrinthine capsule, and the deposition of caseous exudation (Haighton). In my case of osteogenesis in the cavity of the labyrinth, the auditory nerve was unchanged. In a case of progressive deafness lately examined by me, in which anchylosis of the stapes and partial ossification of the cochlea were found post-mortem, the fibres of the auditory nerve were very much atrophied.

O. Weber (*Pitha und Billroth*, i.) found in destruction of the labyrinth fatty degeneration of the auditory nerve, and transmission of the same to the central portion.

The view, that in long-continuing deafness atrophy from inaction must affect the auditory nerve, has not yet been corroborated by experience, the stem of the nerve being often found unchanged, not only in long-continuing anchylosis of the stapes, but also in congenital deafmutism.

Schwartze, in a case of bilateral anchylosis of the stapes, observed atrophy of the nerve only on one side, while the other nerve presented a normal appearance.

On the other hand, secondary atrophy in the expansion of the nerve in the labyrinth and in the ganglion layer of the cochlea, according to my observations, occurs more frequently. An interesting carefully observe dcase of atrophy of the nerve in the first coil of the cochlea with limited movement of the stapes in the fenestra ovalis we owe to Moos and Steinbrügge ; in this case, beside deafness for speech, perception for high tones was markedly diminished.

Not less important is the atrophy of the ganglion layer found in the spiral canal of the cochlea (Rosenthal's canal), which brings about the connection of the nerve-bundles entering the cochlea with those in the lamina spiralis. This change is very prominent in the following case of mine :

The patient was a boy, aged 9 years, who, when 4 years of age, became totally deaf during an acute illness, which lasted eight days, combined with unconsciousness. Death resulted in consequence of acute encephalitis. The necroscopy showed the right middle ear to be normal. In the left membrana tympani there was a large perforation, caused by an exhausted suppuration of the middle ear.

In microscopical sections there were on the inferior coil of the cochlea, at

the place of transition from the first to the second coil, and in Rosenthal's canal (Fig. 318, *a*) a small number of round or angular bodies (*b*), which, upon minute examination, proved to be the remains (nuclei) of the ganglion layer, its cells having in great part disappeared, and only a small portion remaining as shrivelled granular cells (*vide* the illustration of the normal stratum cellulosum in Fig. 308, p. 599). The cavity of Rosenthal's canal is traversed by a fine network, in which only a few traces of nervous tissue are to be seen. The nerve-bundle (*c*) entering into the lamina spiralis ossea from Rosenthal's canal has completely disappeared, and the place where Corti's cells lay is

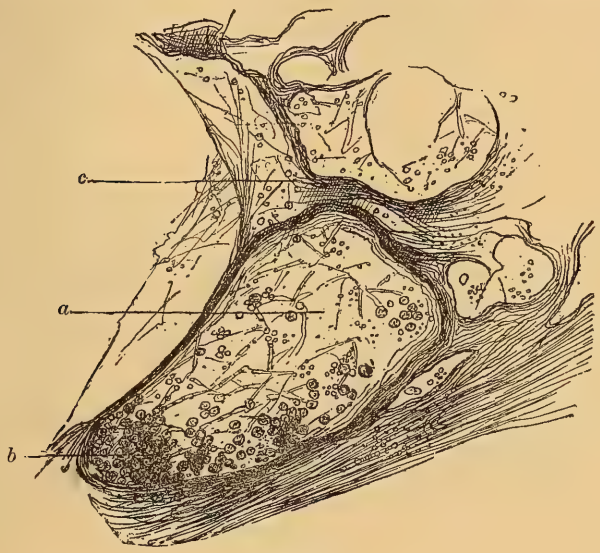

FIG. 318.

marked by a somewhat elevated layer of epithelium. The striæ acusticæ are weakly developed; there were no anomalies present in sections of the auditory nuclei and roots.

Whether, in this case, the atrophy of the ganglion layer and of the nerve expansion in the cochlea were caused by an inflammatory process in the labyrinth during the acute general disease passed through five years previously, or whether it was a case of atrophy from disuse, it would be difficult to say. That the absence of specific irritation of the auditory nerve alone does not necessarily have as a consequence atrophy of the stratum cellulosum and of the nerve-bundle in the cochlea, has been proved by the dissection of several cases of congenital deafmutism, in which I have found the ganglion layer in the cochlea and the nerve expansion in the lamina spiralis perfectly normal.

Habermann saw atrophy of the auditory nerve-endings in the canalis ganglionaris, the lamina spiralis and Corti's organ of the upper coil of the cochlea, from a depression of the skull produced eight years before death. Bezold and Scheibe (*Z. f. O.*, Bd. xxii.) found great atrophy of the nerve fibres and ganglion cells in all three coils of the cochlea in a very deaf man aged 61 years, whose deafness had gradually developed for twenty-three years. An atrophy of the auditory nerve on both sides with anomalies of formation in the membranous labyrinth is reported by Scheibe (*Z. f. O.*, Bd. xxii.).

Colloid degeneration of the auditory nerve was found by Moos in the necroscopy of an idiot with complete deafness on the right side, and on the left deafness of a high degree and hallucinations of hearing, with simultaneously existing anchylosis of the ossicula and osseous closure of the fenestra rotunda.

The occurrence of amyloid bodies in the auditory nerve acquires the significance of a degenerative process only in the case of a particularly large accumulation of corpora amylacea, as they are also found in normal auditory nerves in various quantities.

Calcareous deposits in the periosteum of the internal auditory meatus and in the neurilemma of the auditory nerve were found by Böttcher (*Virch. Arch.*, vol. xvii.) repeatedly in middle-aged people. Moos is of the opinion that in a case with similar post-mortem appearances, the symptoms of disturbance of hearing, subjective noises and convulsions in the facial region, observed during life, may be referred to that.

New-formations in the Internal Ear.

Primary new-formations in the internal ear are much more rare than the secondary ones, which involve the labyrinth and the auditory nerve either from the middle ear or from the cranial cavity.

As to the primary new-formations of the labyrinth, the accounts of them in literature are so deficient and of so little scientific value, that we can merely mention them.

There are some positive communications on a few primary new-formations occurring on the stem of the auditory nerve, but they have more of a pathological interest, as there are no exact clinical observations regarding them. Among recognised primary new-formations of the auditory nerve are to be mentioned sarcoma and the so-called neuroma. The former were repeatedly seen by Förster (*Wurzb. med. Z.*, iii.), and in one case by Voltolini (*Virch. Arch.*, xxii.). The neuromata described by Virchow (*Geschwülste*, ii.) and Klebs (*Prag. Vierteljahrschr.*, 1877) belong in the majority of cases to the gliomata.

In the large majority of cases the new-formations of the internal ear are to be regarded as secondary, extending to the labyrinth or

the stem of the auditory nerve from the middle ear or the cranial cavity.

Of the new-formations of the external and middle ears, it is for the most part the epitheliomata and the malignant round-celled sarcomata that involve the petrous bone and the labyrinth. There are no exact histological observations on the character of the extension of the new-formation in the labyrinth except the following case of secondary epithelioma of the cochlea which was observed by me.

The patient, aged 47, in whom an ulcerating epithelial carcinoma developed on the mastoid, during the course of a year, simulating a chronic middle-ear suppuration, with the formation of polypi. It extended to the petrous portion

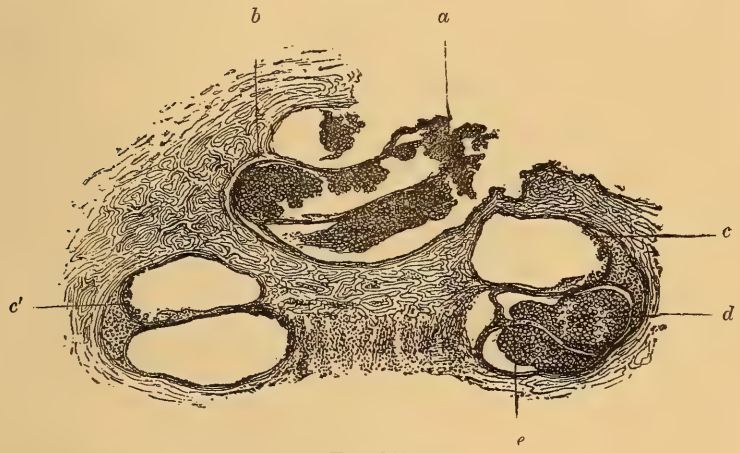

Fig. 319.

of the temporal bone and the cranial cavity, and ended fatally with erysipelas of the face and head.

Microscopical examination of the labyrinth gave the following result:

The apex of the cochlea turned towards the tympanic cavity was opened by cancerous destruction of the inner wall of that cavity (Fig. 319, *a*), the cancerous growth thereby entering into the interior of the cochlea. The lamina spiralis in the second and third coils was here and there broken through, and the scala tympani as well as the scala vestibuli were partly filled up by an accumulation of cancer-cells (*b*).

Of particular interest was the condition of the first coil of the cochlea; the laminæ spirales ossea was intact; in the scala vestibuli, on the external wall of the ductus cochlearis, there was a group of cancer-cells, which extended along the membrana basilaris up to Corti's organ (*c*, *c'*). In the scala tympani of the one side was a lobulated cancerous tubercle (*d*) on the external and inferior wall of the cochlea, which almost filled up two-thirds of the scala tympani. Across the latter there was drawn a connective-tissue cord,

connected with the loosened connective-tissue lining membrane of the inner wall of the cochlea. In some sections the cancerous mass had broken into the internal auditory meatus, in which also the stem of the auditory nerve had become infiltrated with the cancerous growth.

The growths which invade the stem of the auditory nerve or the labyrinth from the cranial cavity are more common. The observations hitherto made relate chiefly to sarcoma of the dura mater and of the brain.

In a man, 66 years of age, who died of pneumonia, and who had become deaf after otorrhœa during typhus, Burckhardt-Merian (*A. f. O.*, xiii.) found a fibrosarcoma of the dura mater which had involved the labyrinth. It originated above the place of union of the inferior petrosal sinus with the jugular fossa, where it divided into two branches, one entering the vestibule as a round cord through the enlarged aqueduct of the cochlea, while the other proceeded under the floor of the internal meatus, partially encircling the necrosed cochlea, to the tunica adventitia of the carotid.

Field describes a case of sarcoma the size of an orange, on the posterior surface of the petrous bone and on the internal auditory meatus, spreading from the dura mater and destroying the auditory nerve.

In a woman, aged 47, who was suddenly attacked by anæsthesia of the left side of the face, weakness of vision in the left eye, lachrymation, ptosis, headache, vertigo, and deafness, and who died a year later with symptoms of suffocation, Moos (*A. f. A. u. O.*, iv.) found a round spindle-celled sarcoma, the size of a walnut, on the external side of the left porus acusticus internus, which was connected with the crus cerebelli and pushed the medulla oblongata to the right. The auditory nerve entering the tumour could only be followed a very short distance. In the considerably dilated internal auditory meatus there lay a second uneven tumour of the size of a pea. Degenerative processes were found on the cerebral nerves, in the cervical and dorsal portions of the spinal cord, and in the terminal expansion of the auditory nerve in the labyrinth.

Vermyne found, as the cause of a consecutive blindness, which followed after seven years of complete deafness, a myxofibroma on the base of the skull that had destroyed the labyrinth.

Virchow (*Geschwülste*, ii., cited by Schwartze) describes a psammoma of the dura mater, the size of a mulberry, which, arising at the entrance of the porus acusticus internus, gave rise to paralysis of the auditory and facial nerves by pressure in the internal meatus.

Schwartze (*A. f. O.*, Bd. v.) found a tubercular growth in a child 2 years of age, which compressed the auditory and facial nerves.

Stevens (*Z. f. O.*, viii.) describes the clinical history and the post-mortem appearances in the case of a girl, 17 years of age, in whom there had existed for a long time convergent strabismus, on the left total deafness, on the right dulness of hearing, imbecility, clumsy movements, drawling speech, unsteady gait, weakness and weight in the right extremities, and pain on the left forehead and occiput, and death resulted after four weeks of coma. There was a globular sarcoma of the cerebellum having bulbous elevations, the sarcoma occupying half of the right side of the cerebellum, from which a process entered the internal meatus. The auditory nerve was lost in the tumour, so

that the connection of its peripheral fibres with their central origin was interrupted.

I have to thank Dr. van Millingen, of Constantinople, for an interesting specimen in my collection of an intracranial tumour (spindle-celled sarcoma) which penetrated the internal meatus. The case was that of a woman who had been completely deaf for ten years, and who had been occasionally insane during childhood. Apart from the extreme length of the auricles (10 cm.) no anomaly of the cranium was noticeable. Three months before her death optic neuritis of both sides developed, with complete blindness, followed shortly after by facial paralysis of the left side and dementia. Death followed under coma and convulsions.

Examination showed (Fig. 320) a somewhat uneven, roundish tumour (*T*),

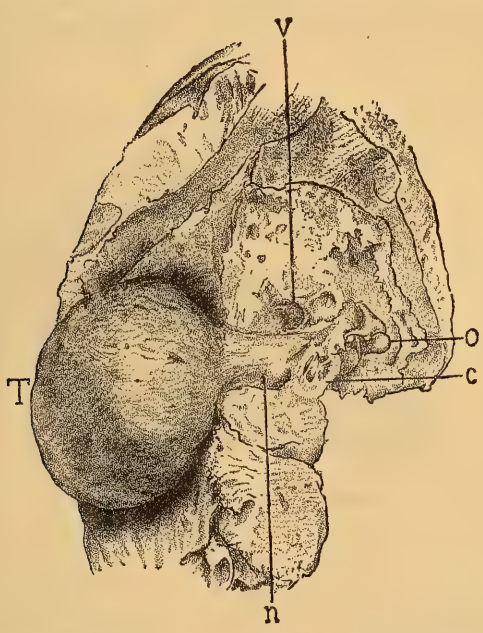

FIG. 320.—SPINDLE-CELLED SARCOMA, THE SIZE OF A WALNUT, GROWING FROM THE AUDITORY NERVE INTO THE INTERNAL MEATUS.

o, Cavum tymp. with malleus and incus; *v*, Vestibule; *c*, Cochlea; *T*, Sarcoma of the auditory nerve; *n*, The new growth extending into the internal meatus.

nearly the size of a walnut, covering most of the posterior surface of the petrous portion of the temporal bone. It surrounded the facial and auditory nerves in the form of a cord, gradually diminishing outwards, and completely filled the lumen of the internal auditory meatus as far as the infundibulum. The auditory and facial nerves entered the tumour here, and the central portion of the nerve could not be distinguished. In the tympanic cavity, as well as in the vestibule (*v*) and in the cochlea, no changes were seen.

Among the rare growths in the region of the internal ear may be reckoned the cavernous angioma of the petrous bone first observed by me.

The case was that of F. N., an innkeeper's daughter, aged 12 years, who had suffered for a year and a half from right otorrhœa and periodical bleedings from the ear. For several weeks right facial paralysis had existed. On admission there was found a bluish-red polypoid growth, which bled profusely on the slightest touch, and extended to the middle of the external meatus; roughness of the bone on the posterior wall of the meatus; great deafness, and perception for the tuning-fork through the bones of the head was better on the affected side. During the observation there was severe hæmorrhage and rapid diminution of the growth.

After remaining two months in my clinique, difficulty of breathing and cyanosis set in, and increased steadily till the third day, when death ensued, with symptoms of suffocation.

Post-mortem Appearances.—The middle of the posterior osseous wall of the auditory meatus was perforated by two irregular openings the size of half a lentil, leading to the cavity of the mastoid process. Through these openings

Fig. 321.

a tumour the size of a pea, and a smaller one, bluish-red in colour and smooth in surface, grew into the meatus. On the posterior half of the membrana tympani there was an oval perforation, through which some ragged growths penetrated.

At the base of the skull, corresponding to the whole of the right petrous pyramid, there was an irregular, tuberculated, ovoid tumour about the size of an orange, projecting forward into the right middle cranial fossa, and backwards into the posterior cranial fossa. This was partially ossified, and in parts the sharp ridges of bone extended into the spongy portion of the tumour.

The entrance of the porus acusticus internus was greatly contracted. The auditory and facial nerves were thin, and of a pale gray colour. On a section through the petrous bone parallel to the posterior surface of the pyramid (Fig. 321), the osseous mass of the latter was found traversed by numerous small and large cavities (*a*), from the walls of which round and irregular excrescences grew into the lumen of the cavities. From the upper section of

the pyramid of the petrous bone (*b*) there arose a radiating osseous framework (*c*), composed of strong osseous lamellæ, to the upper edge of which a large cavernous compartment was attached (*d*), which contained liquid blood and coagula.

The microscopical examination of the polypus, removed from the auditory meatus, showed it to be a cavernous angioma, which was connected with the growth in the petrous bone, in its tissue osseous trabeculæ being found similar to those in the large angioma of the petrous bone. Examination proved the starting-point of the growth to be the lateral sinus, which communicated with the cavities of the cavernous angioma. The inferior halves of the right temporal and occipital lobes were deeply impressed, corresponding to the tumour; the cerebellum and the medulla oblongata were laterally compressed and much pushed towards the left side.

Paralysis of the auditory nerve from pressure will be discussed along with the cerebral disturbances of hearing.

Neuroses of the Acoustic Apparatus.

1. *Hyperæsthesiæ.*

Under this head we have;

1. *Hyper-Acuteness of Hearing* (oxyecoia).—This is characterized by a periodical striking increase of the acuteness of hearing, either for every kind of tone and noise or only for certain sounds. During such phases, which last usually one or two hours, the persons affected are able to hear and understand speech or music from greater distances than usual, or from distant rooms—for example, from the next flat—while other normal-hearing individuals in their company only hear them indistinctly.

Oxyecoia is very seldom met with, and in older authors but little trustworthy information is to be found on this neurosis. According to my observation, it affects chiefly excitable people without any other disturbances of hearing, especially during mental excitement and slight congestion of the brain after partaking of spirituous liquors. Several times a temporary acuteness of hearing has set in after cessation of a slight catarrh of the tube and tympanic cavity. Almost always the affected person exhibited excessive sensibility for noises. Moos observed hyper-acuteness of hearing in one case as the forerunner of an intracranial affection of the auditory nerve, and Urbantschitsch the same in a man at the beginning of a febrile attack, and with great mental disturbance.

2. *Paracusis.*—The qualitative change in the perception of hearing which is most frequently manifested in a false perception of pitch should not always be considered a symptom of a disease of the auditory nerve, for, as we have seen, there may be variations in pitch

of $\frac{1}{4}$ to $\frac{1}{2}$ tone due to the changes of tension in the sound-conducting apparatus during middle ear-affections. Greater differences in perception to the next higher third (Moos) or 1 to 2 tones higher or lower (Knapp, Swan Burnett, Pomeroy, Gruber) are to be considered due to the auditory nerve apparatus being out of tune, and they are specially painful and disturbing in musicians on account of the subjective dissonance in unilateral affections. The difference in pitch of sounds heard by the two ears through air conduction only rarely signifies a similar condition for bone conduction (O. Wolf).

The want of tune of one ear is to be classified with the rarely-occurring diplacusis (Paracusis dipl.), an anomaly of perception in which either each sound or only certain tones are heard twice. I have observed this disturbance of hearing several times with otitis media acuta, with serous middle-ear catarrh, and with chronic middle-ear suppuration. The symptom was transient; twice tones as well as speech were doubly heard, and in another case it was more of an echo which the patient could perceive.

Cases of diplacusis were reported by Itard, Sauvages, Beck, Wittich (observed on himself), Moos, and Knapp, who attempted to explain these symptoms. Barth considers the diplacusis binauralis to be principally due to the middle ear, and that the diseased ear hears no other tone than the normal one, but with a different pitch. Bressler reported an interesting case of double hearing, which Gumpert observed on himself. After a protracted inflammatory ear affection double hearing occurred. He heard spoken words as though they came from two different directions. Both words were perceived without an interval between, the second not being an echo of the first He was only able to distinguish between them by the difference of their tone. That he did not hear double with the diseased ear was distinctly proved by hermetically stopping the meatus of the sound ear.

Kayser (Berl. Congr., 1890) differentiates a diplacusis dysharmonica and echoica. By the first, two tones are perceived, the diseased ear hearing a higher or lower tone than the normal one. By the second form, as described by me above, the sound is heard later and weaker, the same as an echo.

Jacobson disputes Barth's explanation of double hearing, and considers with Wittich that the elastic end apparatus of the auditory nerve is totally or partially out of tune; therefore there is a participation of the labyrinth with the middle-ear affection. In a case of double hearing observed by Treitel, after rupture of the membrana tympani, besides the higher tone the next lower one was heard accompanied by a buzzing noise.

Paracusis Willisii has been described with chronic middle-ear catarrh (p. 289). Paracusis loci does not depend upon an anomaly produced by a change in the auditory nerve, but upon the difference in the acuteness of perception of the two ears. As our judgment of the direction of sound depends upon the binaural hearing in unilateral deafness, the source of the sound will be projected in the direction of the normal hearing ear.

The fact that in some cases a sound—for example, the tick of a watch—is

heard when the source is at quite a distance, while upon bringing it nearer to the ear it will not be heard beyond a certain point, is called an anomaly of perception by Longhi and Braunschweig, giving it the name of 'scotoma auris.' Guye (Brüssel. Congres., 1888) explains the symptom in this manner, that by approximating the source of sound to the deaf ear, 'shadows of sound' are produced which suppress the perception of the waves of sound in the normal ear.

3. *Hyperæsthesia Acustica.*—This name is used to signify an unpleasant, painful sensation in the ear produced by a tone or noise. It exists also in normal ears for the highest tones (Galton's whistle, sounding-rods). Anæmic, nervous, hysterical, neurasthenic, easily excitable individuals, and convalescents after severe diseases, are frequently unpleasantly affected by certain tones and noises. Hyperæsthesia acustica is a frequent accompanying symptom of hemicrania and trigeminal neuralgia, also of beginning or already developed cerebral diseases, especially frequently after meningitis. It is most frequently seen, however, with acute or chronic affections of the middle ear and labyrinth. This symptom is especially striking in the severe forms of middle-ear sclerosis. In these cases the sensibility to noise is frequently in inverse proportion to the disturbance of hearing. I have even observed cases with complete deafness in which hyperæsthesia acustica was still present. It is frequently accompanied by a feeling of trembling, anxiety, dizziness, headache, and nervous agitation.

4. *Subjective Sensations of Hearing.*—The subjective noises in the ear, which are always produced by an irritable condition of the auditory nerve, are brought about either by disease of the ear or reflex irritation from the course of the cranial or spinal nerves to the auditory nerve. It is a very frequent, sometimes almost unbearable, accompanying symptom of ear disease, and we would refer especially to the description of it among the symptoms of the diseases of the external, middle and internal ear.

The subjective sensations of hearing are observed in most cases in the ear itself, but in many cases they are within the head, in the occiput, in the temporal region, or on the vertex. When they occur as attacks, intense noises extend from the ear over the head. This is especially the case in the beginning of the affection, when the subjective sensations may be thought to be objective noises, until experience rectifies the false conception. Hallucinations of hearing (articulate speech, musical melodies) very rarely occur in ear diseases without a changed condition in the brain. It has been proved by experience* that the hallucinations produced by an

* Comp. Köppe, *A. f. O.*, Bd. ix.

irritable condition of the cortex of the brain are made worse by the occurrence of an ear affection, and that in many psychoses the hallucinations may be made better or removed through a proper treatment of the ear affection.

The subjective sensations of hearing are characterized by the patient in different ways—most frequently as whizzing, roaring, buzzing, seething, hissing, singing, ringing, humming, and whistling in the ear. The character of these noises are designated as either high or low by patients who are capable of judging. More rarely they are compared to the noise of a railroad train, the chirp of a cricket, the warble of birds, or (the most rare form of noises) articulated human voices, the barking of a dog, the crashing of plates of glass, the grinding of shears, the cracking of beams, the sound of trumpets, the tone of a low or high violin string, chaotic musical tones, crashing and crackling, the shot of a pistol, the sensation of wind blowing outside of the ear, the blow of a hammer, the noise of a mill, the croaking of frogs, etc. Frequently the objective noises (as the tick of a watch) is not heard as such if they are similar to the subjective noises of the patient. A patient who said he heard the chirp of a cricket incessantly when I imitated the chirp with my mouth was not able to hear it as an objective noise, although his deafness was of a slight degree.

The intensity of the subjective noises is seldom uniform, usually there may be great variations, the cause of which is in the disease process itself, but more frequently lies in external influences or somatic conditions.

Of the external influences which produce an increase of the subjective noises may be mentioned: changes in the weather and temperature, great heat, wind, draughts of air, continued rainy weather, and remaining in closed rooms. In the open air the noises are not so annoying. Diversion and occupation will often cause severe noises to be forgotten, for which reason the ringing will not be heard during the day; while lying in a quiet room at night before going to sleep they are very plain. Loud objective noises frequently cover the subjective completely, so that persons in waggons, upon the railroad, or in noisy rooms do not hear loud ringing in the ear; they appear so much the louder, however, when the surroundings become quiet. I have seen persons who heard their subjective noises in the midst of the greatest commotion. That the louder objective noises could diminish the subjective sensations of hearing was known to the older authors (Plater, Itard), and the observation can be frequently made that by the effect of a tuning-fork upon the ear the subjective noises

are diminished or completely stopped for a short time (Urbantschitsch).

Subjective noises are frequently produced, or increased when present, by temporary alteration of the general system. Bodily and mental excitement, emotion, remaining in a stooping posture, much speaking, coughing and sneezing, the movement of chewing, turning and shaking of the head, keeping awake at night or sleeping too long, the use of spirituous liquors, over-filling the stomach, indisposition, disease, menstruation, gravidity, and parturition, especially things which produce an irritation of the nervous system, will usually increase the tinnitus in a marked manner.

With a healthy condition of the body, repose of the mind, happy disposition, in beautiful, clear weather the subjective noises are felt to be less intense.

The subjective sensations are either intermitting or continuous (p. 155); the continuous noises may begin as such or develop from the intermitting noises, as with the latter the greater intervals at the beginning gradually disappear. Subjective noises occurring in typical regularity are not common, and are usually observed with intermittent fever.

The subjective noises produce unbearable torments in many patients, while others become gradually accustomed to the sensation which was so unpleasant at the beginning.

That form of subjective noises is to be considered as a pure neurosis which is known by the name of 'nervous tinnitus,' or tinnitus without difficulty in hearing. It occurs mostly in excitable, nervous persons, with over-strained mental condition, after trouble, in exhausted conditions, with anæmia, after parturition, after a concussion of sound; occasionally, however, in completely normal individuals. Accompanying sensations of light and disturbances in the nerves of other parts signify a central disease. The patients complain most frequently of ringing, hissing, and buzzing in the ear, yet the noises seldom reach such an intensity as in adhesive processes in the middle ear.

The nervous tinnitus may disappear sooner or later, but frequently continues during the whole life without a disturbance of function. Sometimes, after long observation, it is seen to be the forerunner of a sclerosing, slowly-progressing, middle-ear inflammation or a brain disease.

Subjective sensations of hearing are occasionally produced reflexly from the termination of the trigeminus by neuralgia or hemicrania, more rarely from the facial. They are to be considered especially as reflex symptoms if the tinnitus appears during a neuralgic attack

and disappears again after it is over. That by irritating the skin supplied by the trigeminus near the ear—for example, by rubbing or shaving—the subjective noises may be produced, or existing ones increased or diminished (Benedikt), I have repeatedly observed. In one of my cases, a person who was educated musically, the sensation of certain musical tones could be produced by rubbing the skin near the external orifice of the ear and by swallowing.

Prognosis.—The prognosis of subjective noises depends upon their cause and duration. The noises produced by diseases of the external meatus, acute middle-ear inflammation, and secretive catarrh generally offer a good prognosis. They are unfavourable, however, in sclerosis of the middle-ear mucous membrane, in the severe forms of labyrinth disease with cerebral deafness, and with the arterial noises in the ear which have existed for a long time. The prognosis of intermitting sensations of hearing is good, that of continuous noises unfavourable.

Treatment.—In treating subjective noises the first thing is to consider the cause. That subjective sensations of hearing disappear in many cases after the removal of masses of cerumen and epidermis, granulations and polypi from the ear has already been mentioned. In a similar manner, subjective noises produced by increased pressure in the labyrinth, as is frequently seen with stopping of the Eustachian tube, and with collections of mucus, pus, and epidermis masses in the middle ear, completely disappear upon removing the pathological products. Also those subjective sensations occurring during acute inflammatory processes in the external or middle ear, or through anomalies of tension in the sound-conducting apparatus, are frequently completely cured. On the other hand, the treatment of subjective noises which accompany sclerosis and the formation of new connective tissue in the tympanum, as well as the sensations accompanying labyrinth and brain affections, is without effect in most cases, especially if the noises have continued for months and years.

In spite of that, in the treatment of ear patients we must give attention to this frequently unbearable symptom. For when it is not possible to entirely stop the tinnitus, in many cases the very turbulent noises can be so diminished that they may be borne by the patient.

The effect of treatment upon the subjective noises in chronic ear diseases cannot be determined before trying. In some rare cases the noises cease altogether, in others they are diminished, but in the majority of cases they remain unchanged even when a marked improvement in hearing is secured in the same cases. The decrease

of the noises after the treatment is sometimes permanent; frequently, however, after several weeks or months an increase of the tinnitus returns. Often the noises are made worse where their intensity was diminished if the treatment is continued too long, as too long treatment may even produce subjective noises where they were not present before.

In most cases where the subjective noises are the object of treatment, there is a chronic adhesive process in the middle ear, with or without being complicated by labyrinth disease. The treatment of the subjective noises is here essentially that for the disturbance of hearing. Where the tinnitus is due to an anomaly of tension in the sound-conducting apparatus and the increase of pressure in the labyrinth produced thereby, it will be frequently diminished by inflating the middle ear and by rarefaction of air in the external meatus, but is seldom completely removed.

The effect is most marked immediately after the use of the following methods of treatment, as severe noises often immediately stop or are markedly diminished. These favourable results seldom remain, for after a short time the noises return, but frequently with diminished intensity. A favourable result is obtained in many cases by using my method of inflation, in others by catheterizing or by the rarefaction of air in the external meatus. Sometimes a diminution of the subjective noises is obtained by the injection of medicated solutions or the introduction of vapours (pp. 108 and 122), of sulphuric æther, acetic æther (Kramer), chloroform (Rau), or a mixture of sulph. æther with liq. anæsthetic. Hollandi (6 in 4), iodide of ethyl, spirit. æther nitric., where the air-douche was previously without result. Injections of cocaine muriate (5 to 8 drops of a 2 to 5 per cent. sol.), recommended by Kiesselbach and Suarez di Mendoza, have not proved better than the solutions of sodium carbonate, pilocarpine, etc.

Counter-irritants and vesicants behind the ear were formerly very much recommended, but are now very little used. I have found counter-irritation on the mastoid process of most use with recently occurring noises, and also in ear diseases with continual tinnitus when it has increased to an unbearable degree. Sometimes spirituous applications* on the mastoid process produce a marked alleviation. When the tinnitus is greatly increased at times the application of a fly-blister to the mastoid is indicated in order to lay free the corium layer for the application of Ung. Mezerei or Stibiat., by which a strong irritation can be produced.

* ℞ Spirit. aromat., Spirit. sinapis, āā. 30·0 S. 20 drops applied behind the ear. ℞ Spirit. formicar., Bals. Hofmanni, āā. 30·0 S. Use as above.

In a number of cases, where the objective noises occurred without visible middle-ear affections and the trouble has not existed long, the application of Quinia bisulph. to the vesicated spot will alleviate the noise over-night; in other cases the tinnitus is made weaker for a time with an accompanying diminution of the hearing; often, however, the medicament is without effect.

The external use of narcotics only seldom has an effect upon the subjective noises. Narcotic applications in the region of the ear* are, therefore, only experimentally used when other means have failed.

Subcutaneous injections of morphine are only indicated where from time to time the noises paroxysmally attain a very severe character.

Narcotic instillations in the external meatus are just as uncertain. They frequently produce an increase of the subjective sensations and decrease in the hearing, as the oily substances dry on the membrana tympani and form a thick layer upon it. On the other hand, by painting the cartilaginous meatus with medicated glycerine solutions, especially where it is void of secretion, produces an alleviation of the tinnitus and a subjective easing through reflex effects, I use the following solutions in my practice: ℞ Tr. ambræ, 2·0; Æth. sulph., 1·0; Glycerin. pur., 12·0. ℞ Tr. valerianæ, 2·0; Æth. acet., 1·0; Glycerin. pur., 10·0, D.S. Paint in meatus.

Of the internal medicaments, Sod. hydrobrom. (1 to 4 grammes pro dos.) has proved beneficial in those cases where the sensations of hearing are increased by nervous excitement. The effect of medicines is manifested by a diminution in the noises and in the bringing on of sleep when this has been disturbed by the intense noises. Acid. hydrobromic. (10 to 30 gtt. t. i. d. in sweetened water), as recommended by Woakes, as well as arnica (Wilde), or atropine (2 to 3 milligrammes pro die), only seldom diminish the auditory sensations to a marked degree. If variations in the intensity of the noises are frequent, an occasional diminution cannot be considered as due to the medicament. The internal use of quinine must be limited to cases where the noises occur periodically with attacks of dizziness (Charcot, Guye).

A beneficial effect upon the subjective noises is occasionally observed by the internal use of Pot. hydroiod. (0·5 to 1·0 pro die) in ear affections with constitutional syphilis, where the disease of

* ℞ Glycerini pur., 10·0; Extr. laud. aquos., 0·4. M. tere exactissime D.S. 8 to 10 drops applied behind the ear.—℞ Glycerin. pur., 100; Acet. morph., 0·2, M.D.S. As above.—℞ Olei olivarum, Chloroform, āā. 8·0, M.D.S. As above.—℞ Glycerin. pur., 10·0; Tinct. belladonnæ, 5·0, M.D.S. As above.

the middle ear is complicated by an accompanying labyrinth affection. The effect of the internal medication can be increased in such cases by inunctions of iodine ointment (Pot. iodide, 2·0; Ung. emoll., 20·0; Iodine pur., 0·1), or iodol ointment (Iodol. pur., 1·0; Ung. emoll., 20·0) on the mastoid process.

With pulsating noises, with or without heart affections, I have observed a marked diminution of the noises in several cases from the use of Tr. digitalis (6 to 10 drops), also from Tr. semin. strophanti (5 drops, t. i. d.). Dundas Grant (*Brit. Med. Journ.*, 1887) recommends compression of the vertebral arteries for pulsating noises in the ear.

The treatment of subjective sensations of hearing by tones, as recommended by Lucae,* through the effect of a vibrating tuning-fork upon the ear for 1 to 10 minutes has been only of transient benefit in most of the cases treated by me. Nevertheless, this method may be tried where it is wished to alleviate severe attacks of noises for a time. Lucae proposes the use of high-pitched tuning-forks where the noises have a low-toned character; low-toned tuning-forks, however, where the subjective noises are high-pitched. Jacobson (*Deutsche Med. Woch.*, 1885) has constructed a telephone apparatus for this method of treatment, which is also used for diagnosis.

The electrical treatment of subjective noises will be discussed in the following section.

The so-called entotic noises are to be differentiated from the subjective sensations of hearing, as they are referred to the ear itself, or in its immediate neighbourhood. To these belong: the snapping in the membrano-cartilaginous portion of the Eustachian tube from contraction or clonic spasm of the muscles of the tube; also (p. 55) mucous and rattling noises; the ticking or humming sensations produced by the voluntary or involuntary contraction of the intrinsic muscles of the ear (p. 69). Vascular noises are most common, which are either due to dilatation of the arterial branches in the tympanic cavity, changes in the carotid canal, valvular lesions, aneurisms, venous murmurs, or dilatation of the vessels of the ear. In the latter case, blowing sounds, synchronous with the pulse, can be demonstrated by auscultation of most parts of the head. Prof. Brandt succeeded in producing healing by ligating the temporal artery in a case where objective vascular noises spreading over the whole head occurred after a trauma (*W. med. Bl.*, 1888).

In a man aged 65 years, who had suffered from such severe noises in the right ear that he was only kept from suicide by constant watching, and where the noises ceased upon compressing the external carotid with the finger, Dr. Linsmayer made a ligation of the external carotid. After ligating the

* *Zur Entstehung und Behandlung der subjectiven Gehörsempfindungen*, Berlin, 1884.

noises in the ear ceased for a short time, but hemiplegia of the left side with hemianopsia and left-sided deafness set in, and death occurred after five days from pneumonia. Examination showed an extensive recent softening of the right half of the cerebrum.

2. *Pareses and Paralysis.*

The paralytic states of the auditory nerve, in which there is impairment or absence of the function of hearing, are, as already explained, induced by anatomical changes in the labyrinth, in the stem of the auditory nerve, and in its central course. But there is no doubt, from clinical observations, that functional paralyses of the auditory nerve occur, in which there are no apparent anatomical changes.

Besides the already described forms of disease of the internal ear (hyperæmia and hæmorrhage, inflammation, syphilis, degenerative processes, injuries, etc.), which cause paralysis of the auditory nerve, the following forms are to be clinically distinguished:

1. *Angioneurotic Paralysis of the Auditory Nerve.*—This extremely rare form of disturbance of hearing is characterized by sudden pallor of the face, immediately followed by nausea, vertigo, tinnitus and dulness of hearing, symptoms which entirely disappear after a few minutes, with the return of the normal colour to the face, without leaving the slightest disturbance of hearing.

The following characteristic case is from my practice: A man, 36 years of age, became deaf on the right side, in consequence of scarlatinal suppuration of the middle ear in childhood, with destruction of the membrana tympani. The left ear was quite normal till within six months ago. At that time the patient was attacked by nausea and vertigo, which, however, soon disappeared. Since that time, the almost daily recurring attacks have taken the following form, according to the description of the patient: with the sensation as though something were rushing to the head, the face became suddenly pale, and such violent vertigo set in that he was obliged to steady himself by holding to something. At the same time, a loud sound, like that of a steaming kettle, and a feeling of confusion in the left ear, with a high degree of deafness, occurred, without the least loss of consciousness during the attack. After a few minutes, the subjective noises ceased, the face became slightly red, the vertigo and feeling of confusion passed quickly away, and the normal acuteness of hearing returned.

This statement of the patient I confirmed by the observation of such an attack. I observed excessive paleness of the face, and at the same moment the hearing-distance for the acoumeter was determined as over 3 metres; half a minute later the hearing-distance diminished to 1 cm., and the patient could only with difficulty understand what was said in his immediate vicinity. This lasted for about two minutes; the paleness of the face then disappeared,

the subjective noises became weaker, and a tolerably rapid increase in the hearing-distance for speech and the acoumeter took place. Five minutes later, the normal hearing returned, with the disappearance of the stupefaction and confusion in the head.

From these symptoms angioneurosis of the internal ear, due to the sympathetic, was diagnosed, and galvanization of the sympathetic in the throat was ordered. After use of electricity, the attacks ceased for some days; and by continued treatment they returned less frequently and with less intensity, till after some months they ceased altogether. Whether in this case the group of symptoms proceeded from the labyrinth or from the central course of the auditory nerve, could not be determined.

2. *Rheumatic Paralysis of the Auditory Nerve.*—There are very few trustworthy observations of cases which could with justice be reckoned as rheumatic affections of the labyrinth. To be certain of the diagnosis, the cause, course, and the complication with rheumatic affections in other parts of the body are to be considered.

A case, communicated by Moos (*A. f. A. u. O.*, i.) was that of a girl, 19 years of age, who was attacked by hyperæsthesia of the organ of hearing, shortly followed by total deafness and tormenting subjective noises in the seventh week of acute articular rheumatism, ushered in by violent nervous and cerebral phenomena, the noises soon disappearing without improvement in the hearing. The examination with the speculum gave a negative result. The hearing became gradually normal with the use of the constant galvanic current.

Bing (*W. m. W.*, 1880) relates the case of a woman, aged 47, in whom, after exposure to a draught, complete deafness set in on the right side with subjective noises, and on the left considerable dulness of hearing, without any morbid change being found on the membrana tympani. The vibrations of the tuning-fork placed on the top of the head were perceived only on the left side. Inflations into the middle ear remained without influence on the hearing-distance. Recovery took place within eight days under the internal administration of iodide of potassium, and the application of vesicants to the mastoid process.

Bing bases his diagnosis of acute rheumatic affection of the auditory nerve on the rapid occurrence of the disturbance of hearing, on the absence of objective signs in the middle ear, and on the rapidly favourable course.

In a case examined by me, that of a man, 51 years of age, who had suffered from rheumatism attacking the various articulations and muscular parts one after the other, there suddenly occurred loud noises and excessive dulness of hearing on the right side without vertigo. After four weeks' duration of the disturbance of hearing examination showed: a negative condition of the membrana tympani and of the Eustachian tube; greatly diminished acuteness of hearing for the acoumeter and speech; lessened perception for the acoumeter through the bones of the head; no perception for the tuning-fork through the bones of the head in the affected ear; and a positive result with Rinne's test.

3. *Hysterical Paralysis of the Auditory Nerve.*—Peculiar sensations in the organ of hearing are not uncommon in hysterical subjects. Patients complain frequently of a feeling of constriction and pressure in the ears, of rippling, gushing, and crawling in the interior of the meatus, and of increased sensibility to noises without any perceptible disturbance of hearing.

On the other hand, deafness of undoubtedly hysteric character is very seldom met with, according to the observations hitherto made, perhaps even more seldom than hysterical amblyopia. They are characterized by marked oscillations in the function of hearing, and the rapid change of the accompanying symptoms (v. Tröltsch). There always exists simultaneously anæsthesia or hyperæsthesia of the other nerves of sense as well as anæsthesia or paralysis of the affected side of the body with hyperæsthesia of the opposite side. Würdemann observed partial anæsthesia of the external part of the ear and membrana tympani accompanying it. The whole of the phenomena may disappear periodically, or by the action of transference a rapid transfer of the auditory paralysis and all the other symptoms to the opposite side may take place.

A particularly interesting case of hysterical disturbances of hearing may be related here. It is recorded by Habermann (*Prag. med. Wochenschr.*, 1880), and was that of a boy, 15 years of age, in whom the symptoms of Menière's disease, progressive deafness and blindness, hyperæsthesia of the olfactory nerves, furious headache in turns with complete apathy and insensibility, hyperæsthesia followed by anæsthesia of the right side of the head, and the phenomena of transference, were held to indicate a hysterical affection. Permanent cure is said to have been achieved by the application of pieces of gold to the region of the ear (metallo-therapeutics), and the internal administration of chloride of gold. Ouspensky observed two cases of hysterical deafness with hemianæsthesia of the head and troublesome tinnitus. In one case there existed at the same time perforation of both membranæ tympani after scarlatina, loss of taste and smell, and periodically returning hearing. In both cases the deafness disappeared, and in one the anæsthesia immediately after galvanization of the cervical sympathetic. A case observed by me was that of a young woman, 25 years of age, who was attacked, after great mental emotion, with a gradually increasing left hemiplegia and hemianæsthesia. Rosenthal expressed himself in the following manner: 'The paralytic sensation involved the area of the left trigeminus (its outer and inner branches), as well as of the occipital nerve up to the middle line. The left eye had lost its sensibility and its power of vision (the ophthalmoscopic appearances being normal), the left ear the sense of hearing and the perception of sound conducted through the bones. In the left nostril smell was completely gone, and taste from the left half of the tongue. In its further course there was total motor and sensory paralysis of all the extremities. and bilateral amblyopia; but sensibility gradually returned, first on the left

and then on the right. Yet in later observations during the following year varying increase and decrease of the hearing-distance, once even temporary deafness, amblyopia and hemianæsthesia of the left side, want of galvanic reaction of the auditory nerve, and the appearance of transference, were observed (Urbantschitsch).

Vicarious hæmorrhage from the ear, with attacks of temporary deafness, were observed by Stepanow, Benni, Eitelberg, Ferreri, and Gradenigo; in several cases with chronic middle-ear catarrh.

Besides the enumerated forms of paralysis of the auditory nerve, paralytic states are sometimes clinically observed (rapid deafness of one or both ears with negative objective appearances), which cannot be classed with any of the forms of disease hitherto mentioned, on account of the absence of determined causes and the want of the usually accompanying symptoms, such as subjective noises, vertigo, and disturbances of equilibration. Whether in such cases we have to deal with anatomical changes, or only with functional paralysis of the nerve, cannot be ascertained for want of anatomical data. To the occurrence of pure functional disturbances the rapid disappearance of the disturbances of hearing in some cases would testify.*

Lastly, we must speak of that form of disease of the auditory nerve which may be termed sympathetic paralysis (p. 291). It was formerly thought that in unilateral affections of the ear combined with excessive dulness of hearing, and indeed also in chronic inflammations of the middle ear as well as in diseases of the auditory nerve, sooner or later a disturbance of hearing, with or without tinnitus, developed in the other previously normal ear, which in the absence of objective symptoms pointed to paralysis of the auditory nerve. The diagnosis of a sympathetic disease of the auditory nerve is supported in such cases by the rapidly increasing deafness of the ear, the marked positive Rinne, and the great shortening of the perception for the tuning-fork through the cranial bones.

Treatment of Paralysis of the Auditory Nerve.—This depends upon the cause and the duration of the affection, as well as on the degree of disturbance of hearing and its accompanying symptoms. In recent cases the patient—whether the affection be characterized by tinnitus and increased sensibility of hearing or not—is recommended to avoid all loud sounds, and to remain in a quiet, noiseless room. With a negative state of the membrana tympani and of the

* The temporary deafness may be classed here which Scanzoni repeatedly observed after the application of leeches to the vulva, at the same time with general irritation of the vessels and eruptions of urticaria.

Eustachian tube, at first all local treatment of the middle ear by inflation of air, vapours or injections and the use of electricity are to be avoided, as they often render the condition worse.

On the other hand, a marked improvement in the hearing is sometimes observed after the use of purgatives, stimulating foot-baths, vesicants on the mastoid process followed by the endermic embrocation of an irritant ointment, after the action of the vapour of sulphuric ether (by inserting into the orifice of the ear pledgets of wadding saturated with a mixture of equal parts of sulphuric ether and glycerine), after free perspiration, which is most quickly effected by the subcutaneous injection of 4 to 10 drops of a 2 per cent. solution of muriate of pilocarpine, and after large doses of iodide of potassium ($\frac{1}{2}$ gram. daily).

The chances of great improvement are less the longer the deafness has lasted. In cases, however, in which the affection dates back only some weeks or months, subcutaneous injections of pilocarpine (4 to 6 drops of a 2 per cent. solution, 20 to 25 injections in the course of a month), endermic embrocations of strychnia (4 to 6 drops of a mixture of 1 of strychnia to 10 of glycerine) may be tried on the denuded cutis of the mastoid process. Iodide of potassium may be taken internally, or, in the absence of subjective noises, strychnia (0·07 in 10·0 aqu. dest., 3 to 5 drops three times daily) and the local introduction of vapour of sulphuric ether (pure or with the addition of $\frac{1}{10}$ of liq. ammoniæ) through the catheter into the tympanic cavity may be used, in order to act on the terminal expansion of the auditory nerve. Should these prove fruitless, galvanism may be tried.

The older aural surgeons distinguished between two forms of nervous deafness, the irritative, in which the disturbance of hearing was combined with subjective noises, and the torpid form, in which dulness of hearing existed without tinnitus. The latter form is said to originate spontaneously or to grow out of the former. The description of the irritative form given by Kramer, Rau, Wolf, and others, corresponds almost exactly to the group of symptoms of what we call sclerotizing inflammation of the middle ear. Its treatment consisted in the internal use of small doses of belladonna, digitalis, valerian, and the introduction of the vapours of an aqueous solution of extract of hyoscyamus, of water, acetic ether, and chloroform through the catheter into the middle ear. For the torpid form the internal use of valerian, arnica, camphor, strychnia, and externally sinapisms and moxæ on the mastoid process (Bonnafont), and the introduction of sulphuric and acetic ether vapours into the tympanic cavity were recommended.

Electric Treatment of Functional Disturbances of the Internal Ear by means of the Constant Current.—For galvanic treatment of the ear we require a constant battery, consisting of about twenty elements.

The medium-sized Leclanché element is most suitable. To graduate the current the simple and efficient Kaolin-rheostat of Prof. Gaertner, which has a resistance of at least 200,000 ohms, is used. For measuring the absolute amount a gauging galvanometer (Edelmann's or Schulmeister's pocket galvanometer, or Hirschmann's vertical galvanometer) is necessary. In the circuit there must be a commutator, as reversal of the current (Volta's alternative) is often used for diagnostic and therapeutic purposes. The ear-electrode is variously formed, according to the method of application. Three methods are used: (*a*) the internal application, in which the external meatus is filled with a weak solution of common salt, into which the ear-electrode is dipped; (*b*) the external application, in which the moistened ear-electrode is placed on the lobe or on the edge of the external orifice of the ear; (*c*) galvanization by means of an electric sound introduced into the Eustachian tube. As a rule I use the external application, as the frequent pouring of fluid into the external meatus often gives rise to inflammatory irritation.

The action of the galvanic current on the auditory nerve depends chiefly on the intensity of the current (as expressed in milliampères), and on the individual irritability of the patient. In addition, however, numerous external relations and local contingencies play an important *rôle*, such as abnormal dryness or moistness, hyperæmia or anæmia of the parts, obstacles to the conduction of sound in the ear, as accumulations of cerumen, pus, or fluid, and further, the state of the membrana tympani and of the tympanic cavity, in so far as the current can be modified so as to overcome the hindrance to conduction. Lastly, as Hitzig remarks (*A. f. O.*, v.), it must be kept in mind that the comprehension of auditory sensations varies with the intelligence and individuality of the patient and the sensibility of the normal auditory nerve, which varies within certain limits.

If the auditory nerve reacts to the current, it does so with a sensation of sound, which has a different character in different individuals (ringing, whistling, hissing, etc.). The feeling of dizziness which is produced by the conduction of a current directly through the head, is produced by irritation of the nervous apparatus in the semicircular canals.

Frequent, but not constant, symptoms of the electric irritation of the ear are: stinging pains and burning in the external meatus (trigeminal irritation), facial twitchings (irritation of the facial), formication, sensations of taste, swallowing, salivation and photopasia (irritation of the ending of the optic nerve).

According to Brenner, the normal auditory nerve always reacts to the galvanic current, and in quite a definite way, with sound-sensations, the regular occurrence of which for a certain strength of current, and their constant relation to the direction of the current and its opening and closing, he has employed to establish a law for the electric reaction of the normal auditory nerve.

Brenner's law runs: When the cathode (Ka) is in the auditory meatus, there occurs on closure of the circuit (S) a loud sensation of sound (K'), which continues (D') during the closure and ceases with the opening of the circuit (O). When the anode (A) is in the auditory meatus, neither on closure nor during the continuance of the closure of the circuit is there any reaction, but on opening it a weak sensation of sound is experienced. Brenner distinguishes a primary excitability (E I.), indicated by the number of elements to which the nerve still barely reacts. If this strength of current is in action for a long time, the nerve is soon excited by a smaller number of elements, secondary excitability (E II.), and then also by repeated change of current reaction of the nerve is caused by a still slighter strength, tertiary excitability (E III.). When one introduces a galvanometer in the current it is easily shown that Brenner was mistaken. Not the sensibility but the strength of the current increases, owing to the decrease in the resistance of the skin from the effect of the current.

Schwartze (*A. f. O.*, i.) and Benedikt (*Wr. med. Pr.*, 1870) dispute the general validity of Brenner's data, as, on the one hand, Brenner's normal formula is not always corroborated by perfectly normal-hearing individuals, while on the other it may be present in proved affections of the nerve.

Pollak and Gaertner (*Naturforscherversammlung in Köln*, 1888), and at the same time Gradenigo (*A. f. O.*, xxvi.), have demonstrated that a reaction of the auditory nerve in the normal ear can very seldom be produced by currents of medium strength (to 6 milliampères), while with diseased ears a sensation of sound is produced by a current of the same strength.* Pollak and Gaertner showed farther, that in the cases with a moist condition of the ear (secretive form of inflammation), the auditory nerve reacted from even a very weak current (1 to 2 m.a.), and conclude from this that the state of conduction within the ear must have an important effect upon the production of electrical sound sensations. The normal auditory nerve is well insulated electrically by its osseous cover; in inflammatory processes this insulation is destroyed. Gradenigo's view deviates in so far that he refers the electrical irritability of the auditory nerve to an increased sensibility of it produced by the inflammatory process.

Galvanization of the ear was also recommended for diagnostic

* Chwostek and Pollak found in tetanus, with an otherwise healthy condition of the ear, a constant increased galvanic excitability of the auditory nerve.

purposes, and to ascertain increased (hyperæsthesia) and decreased (dysæsthesia) irritability of the auditory nerve. The diagnosis of hyperæsthesia of the nerve is made when a reaction is obtained by very weak currents, while paralysis of the nerve is recognised when, notwithstanding the application of very considerable currents, which cause twitchings in the region of the facial nerve, no subjective sensations of hearing occur (Moos, *A. f. A. u. O.*, ii.). Against this Wreden gives cases (*Petersb. med. Ztschr.*, 1873), in which, with a hearing-distance for the watch of $\frac{1}{2}$ to 1 metre, no subjective sensations of tone could be obtained even by the strongest currents.

Galvanization of the ear is done in such a manner that the indifferent electrode (usually the anode) is used as the ear electrode, while the other one is placed on some other part of the body, as on the surface of the hand or on the neck. To judge of the irritability of the auditory nerve in special cases the current is gradually increased a little at a time, in order to find the weakest current which will produce a reaction of the nerve. For therapeutic purposes Volta's alternative (repeated changing of current) may also be used in some cases, as well as the gradual increase and decrease of the current. Positive indications for one or the other method of use cannot be determined, as sometimes one method is of use where the other has failed, and *vice versâ*. In each case the use of one method or the other must be tried experimentally. Lately static electricity has been recommended for the treatment of ear diseases, especially by Charcot and his scholars, as well as by Benedikt.

In regard to the curative action of the galvanic current on the organ of hearing the views of specialists differ greatly, as some (J. Pollak) attach great importance to the results of galvanization of the auditory nerve, while a large number of observers are of opinion that this has no lasting influence on the improvement of hearing and the subjective noises. My accumulated experience indicates that galvanic treatment effects a lasting improvement in the function of hearing only in a few cases, and complete removal of the subjective noises extremely rarely; but that very often after longer or shorter treatment the intensity of the subjective noises and their annoyance are lessened for a long time, and that besides, the head-symptoms accompanying ear diseases (heaviness, pressure, giddiness, stupefaction) are either quite removed or greatly improved. It must be mentioned, however, that, according to other observers, aggravation also is sometimes produced by galvanic treatment, the subjective noises becoming more intense, and even after a few sittings great general excitement being induced.

Injuries of the Internal Ear.

The injuries of the internal ear are the result either of direct or of indirect violence. Direct injuries are those which are caused by the penetration of the injuring body (projectiles, sharp instruments) through the external meatus and the membrana tympani into the cavity of the labyrinth.

The traumatic affections of the inner ear caused by indirect violence are much more frequent. They are divided into two groups. The first comprises those lesions which are caused by the immediate action of the violence on the bones of the head and the transmission of the shock to the internal ear, while the second group is composed of the concussions of the terminal expansion of the auditory nerve, produced by sudden condensation of air in the external meatus, or by the action of a loud noise.

Violence applied to the bones of the head may act on the internal ear in two ways: (1) by the extension of a cranial fissure to the petrous bone; (2) by transmission of the concussion to the labyrinth without actual injury of its osseous shell.

Fissures of the petrous bone complicated with injuries of the skull are seldom limited to that portion, but are usually combined with fissures of the tympanic cavity and of the external meatus. With regard to those forms preceded by severe hæmorrhage from the ear, discharge of serous fluid, tinnitus, vertigo, and deafness, the reader is referred to the description p. 553.

That a fissure of the skull may be continued to the labyrinth without involving the middle ear and the external meatus, is proved by the case of a man, aged 40 years, who became totally deaf after a fall on the back of the head, with symptoms of noises in the ears, vertigo, and staggering in the gait, and died seven weeks after the injury with meningeal symptoms. Dissection revealed a ragged fissure of the occipital bone, which continued through both labyrinths and ended close to the inner wall of the tympanic cavity. The left labyrinthine cavity was filled with a dark red mass like coagulated blood; the right labyrinth contained purulent, crumbling extravasation, which penetrated thence through the internal meatus and caused a fatal basilar meningitis. No sign of an injury was perceptible on the dura mater.

Brunner (*Z. f. O.*, x.) published a case, in which, after a fall on the forehead, there occurred total bilateral deafness with violent subjective noises, temporary disturbance of equilibrium, and a serous discharge from the nose. The diagnosis was a fissure of the base of the skull.

Moos described a case of probable fissure of the petrous bone, caused by a stab with a knife between the eye and ear directed towards the squamous portion of the left temporal bone, on which there supervened paralysis of the facial and auditory nerves and temporary irritation of the oculomotor and

vagus nerves. By the use of iodide of potassium and electricity the facial paralysis improved, and the power of hearing gradually returned first for high, then for low tones, and lastly also for speech. Moos is of the opinion that the fissure extending from the squamous portion of the temporal bone passed through either the porus acusticus internus or the facial canal and the osseous capsule of the cochlea. The earlier return of perception for high tones is explained, according to him, by absorption of the discharged exudation taking place earlier in the inferior coil of the cochlea than in its upper part.

In a case reported by Thiery (*A. f. O.*, xxx.) of a self-inflicted shot of the ear which ended fatally from meningitis, the dissection showed a destruction of the membrana tympani and ossicula, with partial destruction of the semicircular canals, but the cochlea was intact. The hearing was said to have been retained, and the only symptom of injury to the labyrinth reported was the disturbance in co-ordination.

That after the application of great violence to the bones of the head without fissure of the bone, excessive disturbance of hearing, subjective noises, giddiness, and staggering in the gait may arise, has been sufficiently proved by experience. The anatomical changes in the labyrinth in such cases are not yet known, but it is probable that hæmorrhage (ecchymosis) frequently occurs, while in other cases paralysis and irritation of the expansion of the auditory nerve may be independently occasioned by the concussion.

The terminations of such concussions of the auditory apparatus are either permanent disturbance of hearing with or without subjective noises, or recovery. In a case reported by Schubert (*A. f. O.*, xxx.) of concussion of the labyrinth from a fall upon the head, complete healing occurred at the end of thirty days. Concussion of the skull has a particularly deleterious influence in those cases in which an ear disease with disturbance of hearing already exists, as even slight concussion may lead to aggravation of the latter.

Blau (*A. f. O.*, xv.) records the case of a man, 27 years of age, who had been deaf in the right ear from childhood owing to an affection of the ear during measles, and who became totally deaf within two hours after a violent blow on the top of the head, the symptoms being roaring noises in the head, ringing of bells, staggering gait, and vomiting. Under the administration of iodide of potassium and derivatives the symptoms disappeared, and in three weeks the patient recovered his former power of hearing.

A very interesting and perhaps unique case of recovery from total deafness caused by concussion of the skull was observed by me. It was that of a man from Aleppo, aged 21, who eleven months previously, on going through a low door, fell down insensible from knocking his head against the doorpost. Consciousness returned after some hours, with headache, tinnitus, and dulness of hearing, which increased at the end of the fourth week to total deafness. His state had remained unchanged for ten months. Exami-

nation showed a negative state of the membrana tympani, a permeable Eustachian tube, and deafness for every kind of noise. The diagnosis was traumatic concussion of the labyrinth, and the prognosis was necessarily unfavourable on account of its long duration and the high degree of disturbance of hearing. The treatment, carried out at the earnest desire of the patient, consisted in injections of a lukewarm solution of iodide of potassium (0·5 in 20·0) into the tympanic cavity. On the third day of the treatment the patient commenced to understand a few words spoken in the immediate neighbourhood of his right ear; from that time the hearing-distance increased a very little on each side till the twentieth day, when a severe headache set in, which caused the patient to keep his room for three days. During the night of the twenty-third day he was suddenly awakened by a violent attack of giddiness, followed by a feeling of concussion in the head, and such a sudden improvement in the hearing that he could hear the ticking of a distant watch. In surprise the patient sprang out of bed in order to inform Dr. Cohen, who slept in an adjoining room, of the occurrence, so that the latter might judge for himself. When he was presented to me on the following day by Dr. Cohen, I found the hearing-distance on both sides to be normal. What was the nature of the anatomical changes in the acoustic apparatus caused by the concussion, whether it was a concussion of the labyrinth generally or a lesion of the central course of the auditory nerve, could not be ascertained from the symptoms. The total bilateral deafness and the simultaneous return of the function of hearing to both ears, were in favour of the latter view. The restoration of hearing must be regarded as incidental, and not as the result of treatment.

With regard to the concussion of the auditory terminal apparatus by sudden condensation of air in the external meatus or by the action of loud noise, the former is most frequently occasioned by a blow on the ear, the latter by violent detonations (as of cannon, guns, pistols, locomotive whistles,* etc.). In cases of condensation of air caused by a box on the ear, the action on the labyrinth is more intense in those cases in which the membrana tympani remains intact, as the whole force of the concussion is transmitted by the footplate of the stapes to the labyrinth; while, when rupture of the membrane follows, a great portion of the active force is expended in causing the rupture. The same holds good for concussions of the labyrinth caused by detonations, which are not combined with rupture of the membrana tympani.

A case observed by Delstanche is very interesting, as showing the therapeutic effect of rarefaction of air in the external meatus for disturbance of hearing due to a sudden air-condensation. It was a labourer, aged 58 years, who received a blow on both ears at the same time from an associate, and immediately became so hard of hearing that he could scarcely hear the voice

* The proposition of Burckhardt-Merian, to make lower-toned locomotive whistles obligatory, appears to me to be very desirable.

in his immediate vicinity. Catheterization and inflation of air were quite useless. A marked improvement in hearing occurred, however, for musical tones as well as speech upon rarefying the air in the meatus with Delstanche's rarefacteur. Delstanche concludes that by the effect of the instrument the footplate of the stapes, which was strongly pressed into the fenestra ovalis, was brought back into its normal position.

On the anatomical changes in the labyrinth, caused by the violent action of sound, there are so far no observations. It is, however, probable that in the majority of cases there is an excessive concussion of the labyrinthine fluid, by which the terminations of the auditory nerve undergo a sudden change of position, in consequence of which they are partly paralyzed, and partly thrown into an abnormal state of irritation.

The symptoms of the labyrinthine concussion vary according to the intensity of the condensation of air or of the sound. Detonations in the immediate neighbourhood of the ear, and in confined spaces, *e.g.*, in covered shooting-stands, are particularly injurious.

In slight degrees of labyrinthine concussion there arises a moderate degree of stupefaction, combined with a subjective singing noise, which again disappears after some hours or days. In severe concussions, on the other hand, great deafness immediately sets in, accompanied by loud subjective noises, confusion in the head, and giddiness. After some days, as a rule, the subjective noises diminish, without any improvement being observed in the function of hearing. Marked hyperæsthesia acustica almost always exists, and the sensation of a shrill, metallic additional-sound in the presence of objective noises (Blau, Brunner).

The perception of sound through the bones of the head is lessened or quite wanting, according to the disturbance of hearing. The vibrations of the tuning-fork from the vertex are always more strongly perceived by the normal ear. This result of the hearing-test, in connection with the cause of origin and the negative appearance of the membrana tympani, determines the diagnosis of concussion of the labyrinth, especially when with deafness of a high degree Rinne's test is positive, and the duration of perception through the cranial bones is shortened.

The termination of severe concussions of the labyrinth is in very few cases recovery, which results only gradually after weeks or months; in most cases a considerable disturbance of hearing, seldom total deafness, remains. The latter may develop progressively out of an originally very moderate disturbance of hearing.*

* The treatment of labyrinthine concussions is similar to that of paralysis of the auditory nerve (see the section on Neuroses of the Internal Ear).

Certain occupations (locksmiths, coopers, tinsmiths), in which continuous noises act upon the ear, cause an irritation and paralysis of the auditory nerve in consequence of the loud constant action of the sound (see p. 154). Gottstein and Kayser (*Bresl. ärztl. Zeitschr.*, 1881), and recently Thomas Barr, among the blacksmiths and smiths examined by them very rarely found normal hearing, and frequently there was a considerable diminution or total absence of perception through the bones of the head. Habermann (*A. f. O.*, Bd. xxx.) found the anatomical source of deafness, in a man aged 75 years, who had worked as a hammerer for twenty years, to be atrophy of the auditory nerve and partial disappearance of Corti's organ.

To the functional anomalies produced by the action of sound may be added that brought about by the use of the telephone, and first called attention to by Blake,* in Boston, then Lannois,† Gellé,‡ and others. The first observations affected such cases as had a disease of the ear which was made worse by the frequent use of the telephone. With the increased use of the telephone observations of ear affections have been made in individuals who formerly had normal hearing. The most frequent symptoms are: hyperæsthesia acustica, subjective sensations of hearing, feeling of pressure and fulness in the ear, and progressive decrease of the hearing. In several cases I have observed a general nervousness which, according to the positive statements of the patients, did not formerly exist. It is probable that the disturbance of hearing and nervous symptoms are induced by the high tones of the telephone, the disturbing associated noises, and the strained attention.

Also, after hearing the phonograph for a long time, I have repeatedly observed deafness, fulness of the head, and sensibility to noise, which disappears, however, after 1 to 2 days.

Those permanent paralyses of the auditory nerve may be classified here, which are described as an accompanying symptom of a general traumatic neurosis from a railway accident (railway spine) (Buss, Baginsky). In five of the cases Baginsky found diminution of the perception for high notes of the tuning-fork and positive Rinne, with intact sound-conducting apparatus.

A medico-legal decision as to the presence of concussion of the labyrinth is possible only in those cases in which there exists at the same time a fissure of the temporal bone extending to the external meatus, where lesion of the labyrinth can be inferred from the discharge of cerebro-spinal fluid, or from the absence of perception of sound through the bones of the head. Those concussions of the labyrinth, on the other hand, caused by direct violence to the skull or by detonation, in which the external auditory meatus and the membrana tympani are both normal, are quite beyond the scope of a medico-legal decision, because: (1) proof cannot be given that the paralysis of the auditory nerve present is the consequence of the

* 'Influence of the Use of the Telephone upon the Hearing-power,' *Arch. of Otol.*, vol. xvii., No. 3, 1888.

† *Annales des Maladies de l'Oreille*, 1889.

‡ *Soc. de Biologie*, 1889.

presumed injury; and (2) even when the action of violence has been established, it cannot be ascertained whether the paralysis were not already in existence before receiving the injury.

Signal-deafness of Railway Employés.—Since Duchesne, of Paris, drew attention, in the year 1857, to the frequent occurrence of deafness and subjective noises in engine-drivers, the subject has undergone a thoroughly scientific examination in the last decade, initiated by the communications made by Moos.

Moos, and later Bürkner, sought for the cause of the disorders of hearing among engine-drivers in the continual severe shaking to which they are exposed, and the persistent straining of the ear, in the piercing draughts, and the continued irritation of the pharynx by the inhalation of injurious vapours escaping from the engine. Moos found the anatomical basis of the dulness of hearing, in the majority of cases, to be the chronic sclerotizing form of inflammation of the middle ear, and this was afterwards confirmed by Schwabach and Pollnow (*A. f. O.*, xvi.), Hedinger (*Deutsche Med. Wochenschr.*, 1882), and Güterbock.

As the dangers of railway traffic which arise from this excessively frequent progressive diminution of hearing in engine-drivers and stokers are, according to Moos, Schwabach, and Pollnow, very great, they proposed that the directors of railways should have at periodical intervals of two to three years the ears of their employés thoroughly examined by a specialist. The opinions of Hedinger, Jacoby, and Güterbock are quite opposed to that of Moos; from their practical observations, they affirm that railway travelling is not at all endangered by a moderate decrease of hearing in the engine-men, as the acoustic signals, which must be understood by railway officials, are so loud that it is only when the hearing is very defective that they cannot be heard.

A later proposition of Moos (*Z. f. O.*, Bd. xi.) is that the limit of auditory acuteness should be determined, by which the safety of railroad traffic would not be made dangerous. As many disturbances of hearing develop in service, according to my view, such testing is only of value if it is repeated at regular intervals.

The treatment of injuries and concussion of the labyrinth is given with the treatment of subjective sensations of hearing and paralysis of the auditory nerve.

Testing for Simulated Dulness of Hearing and Deafness.—The importance of the subject, both in medico-legal practice and for army surgeons entrusted with the examination of soldiers and of those liable to be called out for active service, sufficiently explains the many endeavours to devise a trustworthy method of examination, by which it could be ascertained with certainty whether in a given case genuine or simulated dulness of hearing or deafness has to be dealt with.

According to the observations made by Brigade-Surgeon Chimani on men liable to serve, the simulation of absolute deafness is less

frequent than that of unilateral or bilateral dulness of hearing. This is explained by the fact that the total deafness of an individual is generally known, and the truth concerning it more easily ascertained by inquiry than in the case of dulness of hearing, more especially when the latter affects only one ear. In really existing defects dulness of hearing is most frequently exaggerated.

The method of testing for the detection of simulation must always be preceded by the examination of the membrana tympani and of the Eustachian tubes. If considerable changes are found, which indicate an affection of the middle ear, in such cases the principal requirement is to ascertain the degree of disturbance of hearing, as the capability or incapability of soldiers depend upon that.

In the presence of inflammatory changes in the external and middle ears, it must be noted whether these are not artificially produced and maintained in order to escape military duty. According to Chimani, these affect almost exclusively the external meatus, less frequently the middle ear, and never the internal ear. Artificial inflammations of the external meatus and of the membrana tympani are usually caused by cauterization, and are distinguished from those spontaneous affections by the peculiar form of the disease as well as by its course, the artificial inflammations healing in a very short time, when all further irritation has been rendered impossible by means of a bandage. Sometimes also foreign bodies are intentionally inserted into the external meatus, either to feign a disease of the ear, or, in cases of pretended dulness of hearing, to pass through the testing process the more easily.

The difficulty is greater in cases in which there are no objective indications of an affection of the middle ear, as then we are limited to the investigation of a circumscribed affection of the fenestræ of the labyrinth or of the nerve, the diagnosis of which is often surrounded with great difficulties.

A number of methods of examination have been proposed for the detection of simulated disturbances of hearing with negative conditions of the middle ear, and these will be briefly described.

It must, however, be remarked at the outset that even although the premises are very excellent upon which several of the methods are based, only very few of them can stand the test of experience, especially when a cunningly-devised plan of dissimulation has to be overcome, as is so frequently the case.

The procedure varies according as the dulness of hearing or deafness simulated is unilateral or bilateral. In cases in which a unilateral deafness is said to exist, it must first be ascertained whether the affected ear is quite deaf or capable of hearing to a certain degree. In the latter case, by closing the other ear and bandaging the eyes, the hearing-distance of the deaf ear must be measured by the acoumeter or by a loud clockwork, *e.g.*, a metro-

nome, and the test must be repeated several times in succession. If the hearing-distance on repeated measurement varies but little, dissimulation may be excluded, as a normal-hearing ear is not able to judge of the distance of a source of sound within certain limits. Great differences in the distances given by the various measurements will, however, immediately excite suspicion. This method, which Dr. Chimani has, at my suggestion, used for a number of years, is preferable to the similar examination by speech, on account of the constancy of the source of sound. Chimani attaches great importance to repeated testings on different days and to the short duration of the testing, the results being accurately noted each time.

Chimani (*W. m. W.*, 1869, No. 33) and Moos used the following proceeding with advantage for the detection of unilateral feigned dulness of hearing. A vibrating tuning-fork of large size (c^2) is alternately held at an equal distance from each ear, and naturally the sound is better heard by the sound ear. The vibrating fork is then placed on the middle line of the vertex of the head, or on the front incisor teeth, and the question put to the individual under examination, 'In which ear is the tone better heard?'

The really deaf person (suffering from an obstacle to the conduction of sound),' says Chimani, 'will without hesitation declare that he hears the tuning-fork solely or much more loudly with the affected ear, while the malingerer usually considers a moment and then affirms that he can make out no difference between the loudness in the one ear and in the other, and believes it is the right thing when he says the tuning-fork is heard only by the healthy ear, and not at all by the diseased one. The external meatus of the healthy side is then closed with the finger, and the vibrating tuning-fork again placed on the top of the head; the actually deaf person will say that the tuning-fork is better heard on the stopped ear, or it may be that he cannot distinguish by which ear it is more distinctly heard. The malingerer will state immediately that, now the sound ear is closed, the tone is no longer heard, or only faintly so, by the open and diseased ear.

A complicated, but in some cases successful, procedure has been proposed by Lucae, and turned practically to account by Teuber. The contrivance consists of two metal tubes inserted through a wall separating two rooms, and each leading to an india-rubber tube provided with a side-branch; the india-rubber tubes are intended for the ears of the person to be examined, while the two side-tubes are destined for two witnesses, who have to check the statements of the patient. On rapidly speaking alternately into the two metal tubes, a person really deaf in one ear only hears the echoes of the words perceived by the normal ear, while the malingerer is not able to separate the quickly-changing impression on the right and left ears, and words which were spoken through the tube corresponding to the deaf ear will be said to have been heard. L. Müller's method is based on the same principle, *Berl. klin. Wochenschr.*, 1869), but he uses two short tubes in place of the long one.

Cammon's binaural stethoscope, used by David Coggin in one medico-legal case (*Z. f. O.*, viii.) for detecting simulated unilateral deafness, is as sensible as it is simple; he expresses himself upon it as follows: 'The patient affirmed that he was deaf in the left ear. I therefore inserted a tightly-fitting wooden

plug into the right rubber tube, and then put the two rubber tubes into the metal ones. When I tried the instrument on myself, I found that words spoken could not be understood by the right ear. After the patient had adjusted the stethoscope, he repeated without hesitation the words which I had whispered into the bell of the instrument, which served as a mouth-piece. The tube containing the plug was then taken out of the right ear, which was firmly closed by pressure on the tragus. When I again spoke into the stethoscope, which was still in connection with the left ear, the patient positively assured me that he could no longer distinguish the words. He was of course aware that the tube through which he had before heard was no longer in connection with the right ear.'

In feigned bilateral dulness of hearing the acoumeter or the metronome is used for deciding the hearing-distance, as each ear can be examined separately, the eyes being closed and the examination conducted just as for simulated unilateral dulness.

It is more difficult to unmask pretended bilateral total deafness. The largest contingent of this class of malingerers is furnished by those who are called out for the first time. As physical tests of hearing are of no use in these cases, various devices must be resorted to in order to discover the deceit. Whether the man can be wakened out of sleep by a moderately loud call, seems to me the surest experiment. But as in total deafness motor reflexes may be elicited by the concussion of loud sounds, care must be taken not to go too near the person concerned, and not to call too loudly. In some cases, as Burckhardt-Merian observes, the expression of the malingerer's face, when offensive remarks are made behind his back by a third party, may reveal the deceit. The trick of telling the individual to go, that he is unfit for duty, is very old, and therefore scarcely effective.

In the majority of cases, this, as well as numerous other proposed methods, is of no avail, as very often one has to do with proficient swindlers, who adhere obstinately to their firmly-laid plan of dissimulation.

The experience and the practised eye of the examiner, acquired through many years' practice, are not to be undervalued as qualifying him to discover dissimulation, by gathering a series of proofs from apparently insignificant circumstances. The glaring contradictions made by a number of malingerers on repeated examination, in regard to the cause of origin and course of the disease, are often sufficient to raise suspicion. Frequently the altered, anxious or morose expression of the person examined will suggest the thought of a simulation or exaggeration, as persons who are truly hard of hearing or deaf go through the examination with indifference (Tschudi). Chimani attaches great importance to the observation of the individual himself, his mental faculties, his temperament, the peculiarity of the expression of his face, and of his speech, all which, taken in connection with the results of the hearing-tests, lead in most cases to the detection of malingerers.

Cerebral Disturbances of Hearing.

Diseases of the brain and its membranes are oftener combined with disturbances of hearing than has been hitherto supposed.

Even in the new and larger works on the diseases of the central nervous system, notwithstanding careful description of the disorders of the other nerves of sense, there is but scant and faulty information on the participation of the ear in these pathological processes. It is only in the last few years that great attention has been paid to this subject, so that the number of cases carefully examined clinically, in which the disturbance of hearing had been observed and followed from its very commencement, is too small to form the basis of a pathology of the cerebral disorders of hearing.

These disorders are caused either by affections of the auditory centres; or by morbid processes in the brain or its membranes involving the nucleus, the roots, or the stem of the auditory nerve; or, lastly, by extension of inflammatory processes from the cranial cavity to the labyrinth.

Disturbances of hearing in consequence of simple meningitis are on the whole rare. As anatomical bases of the deafness there have been recognised purulent inflammation of the ependyma and softening of the floor of the fourth ventricle, purulent infiltration, fatty degeneration and shrivelling of the stem of the auditory nerve.

Deafness appearing in simple meningitis is perceived immediately after the return of consciousness between the third and eighth weeks of the disease, or it develops more or less rapidly during convalescence. It is only in exceptional cases that the disturbance of hearing is combined with unilateral or bilateral blindness, strabismus, and with paralysis of other nerves (Knapp). Children become, as a rule, quite deaf, and after months still exhibit an unsteady gait. In adults, on the other hand, there is rarely total deafness; but there often remain subjective noises and disturbances of hearing of various degrees, which very seldom completely disappear. Some time after convalescence a considerable improvement sets in, which, however, is followed in the course of months, or even years, by a progressive deterioration. That disturbances of hearing from hæmorrhagic exudation into the labyrinth also occur with pachymeningitis hæmorrhagica (Moos) has already been mentioned.

Disturbances of hearing are much oftener observed as sequelæ of epidemic cerebro-spinal meningitis. Among the anatomical changes which in this form of disease are associated with disturbance of hearing are: softening or thickening of the ependyma of the fourth ventricle, purulent infiltration and softening of the auditory nerve (Knapp), embedding of the latter in meningeal exudation (Schwartze), shrivelling of the nerve stem, and lastly purulent inflammation of the membranous labyrinth, the origin of which can be traced to transmission of the inflammation either

along the sheath of the auditory nerve (neuritis descendens) or through the aqueducts.

According to Habermann, the diplococcus pneumoniæ enters the internal ear, principally through the aqueductus cochlea in cerebro-spinal meningitis (*Zeitschr. f. Heilkde.*, 1892),

Heller (*Deutsch. Arch. f. klin. Med.*, vol. iii.), in a man, aged 42 years, who died from cerebro-spinal meningitis, found both tympanic cavities filled with pus, and pus in the vestibule also. The membranous semicircular canals, the ampullæ, and the lamina spiralis of the cochlea, were covered with pus-cells.—In a woman, aged 45 years, who also had died of purulent cerebro-spinal meningitis, Heller found numerous punctiform ecchymoses on the lamina spiralis, which was infiltrated with pus. The auditory nerves were infiltrated by pus cells.

In the case of a man, 40 years of age, observed by Lucae (*A. f. O.*, vol. v.), along with purulent cerebro-spinal meningitis there was purulent infiltration of the auditory nerves, the saccules, ampullæ, and semicircular canals.

Habermann (*Zeit. f. Heil.*, Bd. vii., 1886), in a case of recurrent cerebro-spinal meningitis where complete deafness occurred from the first attack, found, beside the usual changes which occur with meningitis, complete destruction of the internal ear, its place being filled with granulation tissue. Suppurative infiltration of the rami cochlearis and vestibularis, destruction of the annular ligament of the fenestra ovalis and articulation of the stapes; and filling of the aqueductus cochlea with granulation tissue, completes the picture of this case of otitis interna due to meningeal suppuration. A second case (*Z. f. Heilk.*, 1892) affected a child seven months old with recent acute cerebro-spinal meningitis, by which the suppurative inflammation due to the specific diplococcus was transmitted through the aqueductus cochlea to the perilymphatic spaces of the labyrinth. The membranous structure was partially destroyed.

In a case of cerebro-spinal meningitis with severe deafness examined by Schwabach (*Zeitschr. f. kl. Med.*, Bd. xviii.) he found purulent perineuritis of the auditory nerve, hæmorrhagic and purulent inflammation combined with the growth of granulations in the scala tymp. of the cochlea and on the lining of the vestibule.

Steinbrügge (*Naturforscherver. zu Berlin*, 1886) has come to the conclusion, from finding two separate conditions upon the post-mortem examination of cases of otitis interna due to cerebro-spinal meningitis, that the two processes must be separately considered: namely, the suppurative inflammation extending from the meninges and a primary necrosis of the membranous labyrinth which comes from the direct effect of the specific excitant of the disease upon the periosteal vessels of the labyrinthine cavity. Through the occurrence of stasis and thrombosis in these vessels, the necrotic destruction of the periosteum and the membranous structure attached to it is produced. The changes in the ear produced by cerebro-spinal meningitis were shown by a recent observation by Fr. Schultze (*Virch. Arch.*, Bd. cxix., H. 1) of a child who died five years after the disease of the brain which rendered him deaf and dumb. There was atrophy of the auditory nerve as far as its

entrance into the medulla oblongata, complete loss of Corti's organ and ossification of the cochlea and semicircular canals, but the auditory nucleus was intact. The deafness produced by cerebro-spinal meningitis, develops in most cases in the first or second week, seldom after several weeks or months (Knapp and Moos).

The intensity of the disease appears to have less influence than its epidemic character. While very severe cases have often occurred without any disturbance of hearing, total deafness has frequently set in in the slighter so-called abortive forms. Gottstein observed total deafness in patients during an epidemic of cerebro-spinal meningitis, who complained for a few days of depression, headache, stiffness of the neck, or where the violent symptoms (fever, vomiting, convulsions, unconsciousness, contractions of the neck) disappeared so rapidly that the patient could get out of bed in two or three days. On the other hand, from the communications received from doctors who had opportunities of observing large epidemics, it seems that in many epidemics disturbances of hearing occur only exceptionally, while in others most of those who survive are deaf.

Similar observations have been made in various parts of Germany. Dr. Roth, in Ziemssen's *Handbuch* (vol. ii., p. 530, cited by Moos), observes that in the Bamberg Deaf and Dumb Institution forty-two pupils, admitted from the district of Oberfrank in the year 1874, became deaf and dumb from cramp in the neck. The town of Bamberg itself, in which the epidemic is said to have been very severe, presented only four cases. Of nine cases admitted in 1875, eight had become deaf in consequence of cerebro-spinal meningitis, and in 1876 the same disease sent eight more cases.

Deafness after epidemic cerebro-spinal meningitis is bilateral in the majority of cases. When the two ears are unequally affected, the one ear is generally quite deaf and the other very hard of hearing. According to Kirchner, even with total deafness for speech and tones, many scratching and grating sounds are remarkably well heard.

The most striking symptom accompanying the deafness is the staggering gait. Moos observed it in half of his cases; according to my notes disturbance of equilibration was present in more than two-thirds of the cases. It lasted the longer the younger the individual was at the time he was attacked by meningitis. In the majority of cases the unsteady gait disappears gradually after three or four months, but it may continue over a year.

Subjective noises are frequent in adults. In children, who seldom complain of tinnitus, they appear to be less disturbing.

In some cases the deafness is complicated with unilateral or

bilateral disturbance of vision, with disturbances of speech, and paralysis in other nerve areas.

The *prognosis* is generally unfavourable. There is very seldom complete recovery. Moos has rightly observed, however, that the percentage of cured and improved cases attended by the general practitioners dwelling in the place during the epidemic, is much greater than that observed by the specialist to whom the patient is taken weeks or months after the epidemic. Cases of deafness, in which during convalescence or several weeks later the power of hearing so improves in one or both ears that speech can be understood at a short distance off, are not often met with. According to Moos, circumstances of favourable prognostic import in regard to improvement in the hearing are, subjective noises during convalescence and the perception of high musical tones. The return of hearing for speech is not always permanent, as I have observed total deafness set in again after months or years.

The *treatment* of cerebro-spinal deafness is almost always unsuccessful. When the symptoms of ear trouble appear in cerebro-spinal meningitis, Leiter's cold water apparatus should be applied over the region of the ear and mastoid (Kirchner). In recent cases, however, an attempt must be made to bring about the absorption of the as yet unorganized exudation. For that purpose iodide of potassium (0·5 to 2·0 gram. per day) or iodide of ammonia (ammon. iodid. 5·0, mist. gummos. 100·0; Syr. cort. aur., 15·0, sig. one tablespoonful three times a day), or the internal use of pilocarpine (4 to 6 drops of a 2 per cent. sol., or 2 to 4 drops subcutaneously) should be prescribed, and the application of an iodine, iodoform, or iodol ointment on the mastoid process, and when circumstances permit it a course of some iodine bath used both internally and externally. The internal and external exhibition of strychnia (p. 672) has hitherto been without effect, and likewise electricity, which Moos only uses in those cases in which a certain degree of hearing remains.

Disturbances of hearing proceeding from affections of the brain are caused by many pathological processes. The most important of these are: hæmorrhage, emboli and embolic softening, encephalitis, chronic sclerosis, acute and chronic hydrocephalus, gummatous and tubercular accumulations, and new-formations in the brain and at the base of the skull.

The occurrence of disturbances of hearing in these processes depends less upon the extent than upon the seat of the pathological accumulation. While with extensive morbid accumulations in the brain substance (abscesses, hæmorrhagic accumulations, growths)

disturbances of hearing are often absent, they are very pronounced with pathological changes of small size when these affect the acoustic cortical centre in the temporal lobe, the connection of the latter with the acoustic nucleus, the acoustic nucleus itself, or the central fibrous course of the auditory nerve. Deafness has been seen several times with diseases of the medulla oblongata and the fourth ventricle ; in other cases, however, it was absent (Ladame).

Disturbances of hearing proceeding from apoplexy of the brain have hitherto been rarely observed. According to Moos, they occur most frequently in hæmorrhage in the pons and in the cerebellum. A case of crossed cerebral deafness of the left ear from softening of the right half of the cerebrum after obliteration of the middle cerebral artery was observed by Kaufmann (*Berl. kl. Wochenschrift*, 1886). According to the observations of Itard, Oppolzer, Andral, v. Tröltsch, and Nothnagel, subjective noises are often the forerunners of apoplexy. Wernicke and C. Friedländer observed a case of total bilateral deafness due to symmetrical gummatous soft deposits in the region of the corona radiata of both temporal lobes, complicated with temporary aphasia.

Acute hydrocephalus internus often causes great disturbances of hearing. These are the result of inflammatory changes on the floor of the sinus rhomboideus, which lead to softening and shrivelling of the nucleus of the auditory nerve. That in acute dropsy of the ventricles of the brain the anatomical changes in the acoustic nuclei may completely recede, is proved by those cases in which total deafness and also blindness, arising in the course of the disease, have completely disappeared. Acute as well as chronic hydrocephalus internus frequently occasions permanent bilateral deafness and deaf-mutism. Meyer found (*Virch. Arch.*, xiv.) in a person congenitally deaf, but with normal hearing organs, the residue of a fœtal ependymitis in the form of knotty and nodular thickenings of the ependyma of the sinus rhomboideus, with obliteration of the striæ acusticæ and destruction of the commencement of the auditory nerve. In chronic hydrocephalus the deafness is occasioned by atrophy of the origin and of the stem of the auditory nerve from pressure (see case on p. 650).

We come now to those peculiar disturbances of hearing which are occasioned by pathological changes in the temporal lobe (cf. Munk's experiment, p. 609). In several cases recorded by Wernicke, Kahler and Pick, Broadbent, and others, in which dissection revealed great changes in the left temporal lobe, it was observed during life that the patients although hearing speech were not able to understand it. This led Wernicke to the conclusion that the

centre for the sense of hearing lay in the cortex of the left temporal lobe, and that there also the excitations of the auditory nerves are united to form sound-pictures, and the acoustic representation of words. When this centre is paralyzed—with an otherwise normal condition of the ear and of the auditory nerve—impressions of sound could still be perceived, but spoken words could not be understood, a condition which was named 'sensory aphasia' by Wernicke, and 'word-deafness' by Kussmaul.* The surprisingly frequent coincidence of word-deafness with disease of the first convolution of the left temporal lobe (like aphasia with lesion of the third left frontal convolution) makes it more than probable that the acoustic representation, or picture of words, is formed principally in the left temporal lobe and in the aforesaid convolution. This opinion, first stated by Wernicke, has since been supported by the observations of Kahler and Pick, Kussmaul, Huguenin, Fritsch, N. Weiss, Drozda, and others. The results of clinical observations, however, and also of physiological experiments (Munk's experiments), showing that after destruction and even extirpation of the cortex of the temporal lobe the understanding for what is heard may be recovered, are by no means in favour of a sharp limitation of the acoustic cortical centre; they lead rather to the conclusion that other groups of ganglion cells presiding over the hearing function must exist in the cortex of the brain, by means of which patients as well as animals experimented on begin again to learn to hear after the loss of the proper hearing centre.

According to Luys the right temporal lobe may vicariously assume the function of the left and do away with the word-deafness.

That word-deafness may also occur without changes in the temporal lobe is shown by a case observed and dissected by Finkelnbach. In this case the claustrum, which is in intimate connection with the cortex of temporal lobe, the lenticular nucleus and the first two frontal convolutions were the seat of a pathological softening.†

According to Stricker (*Vorlesungen*, Part iii., 1880) word-deafness is not only associated with lesions of the temporal lobe, but is also an essential symptom of destructive processes in Broca's speech-island (third left frontal convolution). Since Stricker, from his investigations, has come to the conclusion that word-pictures are purely motor in nature, and are elicited by the transmission of excitation from the various sensory centres (in the hearing of

* In Kussmaul's *Störungen der Sprache* (Leipzig, 1877) there is a very interesting account of Dr. Lordat, who, after his recovery from a long-existing aphasia, said that during the continuance of the disease words spoken fell meaningless on his ear, and that he was not able to understand anything printed or written.

† An interesting condition was found in a case reported by Fergusson (*Journ. of Anat. and Physiol.*, 1890), in which complete deafness of the left ear without word-deafness was present with a tumour in the first right temporal convolution.

speech from the hearing-centre, in reading from the seeing-centre), therefore, by destruction of the motor-centre of speech, word-deafness and word-blindness, along with agraphia and alexia, must necessarily occur, as the seeing and hearing impressions are no longer able to call forth the corresponding word-pictures in the paralyzed centre of speech.

According to this, word-deafness, arising from lesion of the first temporal convolution, may be explained by the fact that the conduction of acoustic stimulations from the side of the hearing-centre to the motor-centre for speech is destroyed, and, therefore, can no longer form word-pictures. The total deafness, which is combined with aphasia, may completely disappear, while the aphasia alone remains, as was observed in a case by Holländer.

Nothnagel considers it probable that similar conditions are present to those in the eye, and one must differentiate in a case of disturbance of hearing: first, simple cortical deafness; second, mind-deafness, in which the patient does not understand the significance of impressions of sound, that is, he does not only fail to understand the spoken word, but also the ripple of a brook, the bark of a dog, the sound of horses' hoofs, etc.; and third, the true word-deafness, in which the patient possesses the understanding for all impressions of hearing, except for the sound-pictures.

Rumpf* states that word-deafness does not occur very frequently from syphilitic brain disease, and also states that it may occur as well from gummatous disease of the cortex as from the formation of syphiloma in the corona radiata, and is usually combined with hemiplegia. Transitory word-deafness of short duration may appear from embolism of the middle meningeal artery, when a disturbance of circulation in the cortex of the temporal lobe is produced thereby.

Of cerebral diseases tumours of the brain are most frequently associated with disturbances of hearing, which are due to pressure, pulling, separation, or disorganization of the central course or stem of the auditory nerve. Paralysis from pressure is principally caused by growths in the posterior section of the base of the brain and of the cranium, originating in the dura mater and the pia mater, and by tumours of the brain itself pressing towards the base. The most common tumours are the sarcoma, myxoma, glioma, carcinoma, and syphilitic gumma (Lagneau, Jackson), the psammoma, and cholesteatoma being more rare.

According to Moos the intracranial pressure produced by a tumour may indirectly bring about disturbance of function in the stem of the auditory nerve. Also the chronic basal meningitis which almost always occurs with tumours of the brain, and the ascending neuritis acustica produced thereby, are answerable for the succeeding deafness. According to Gradenigo (*A. f. O.*, Bd. xxvii.) with intracranial increase in pressure there is a lymph stasis in the stem of the auditory nerve, which is visible anatomically, similar to that seen in the papilla of the optic nerve. Gradenigo says he has seen similar changes with acute nephritis.

* *Die Syphilitische Erkrankungen des Centralnervensystems*, Wiesbaden, 1887.

The statistics of Calmeil, which place the frequency of disturbances of hearing in tumour of the brain at one in nine, and of Ladame, who recorded such disturbances seventeen times among one hundred and seventy-five cases, scarcely give the proper proportions, as unilateral deafness is very often overlooked by clinicians; and, further, in the majority of cases it was not ascertained whether coincident changes in the sound-conducting apparatus were not the true cause of the deafness. From Ladame's compilation, however, it is noteworthy that tumours of the pons are most frequently accompanied by disturbances of hearing, while tumours in the parietal and occipital lobes and in the fourth ventricle have not once caused deafness. The latter cases can only be explained on the ground that no pressure has been exercised by the growth on the nuclei of the auditory nerves.

The most prominent symptoms of the changes within the area of supply of the auditory nerve, caused by cerebral tumours, are: subjective noises, vertigo, and dulness of hearing of various degrees up to total deafness, with which, as a rule, the subjective noises are lost. In many cases I have seen slight facial paresis as an early symptom with dizziness and tinnitus. In the majority of cases the deafness is unilateral (Cruveilhier, Wernicke), but cases are not uncommon in which bilateral deafness is caused by pressure on the opposite half of the brain or by extension of the tumour to the other side. Concomitant symptoms are giddiness, feeling of pressure and pain on the half of the head corresponding to the seat of the tumour, and sparks before the eyes; in its further course there develop marked functional disorders of the optic and other nerves of sense, motor and sensory paralysis in the region of the cerebral nerves (in one of my cases there occurred xerosis, with ulceration of the cornea). The order of the appearance of the separate symptoms depends upon the place of origin and the direction of the growth of the tumour. Then, in a series of cases, disturbances of sight and paralysis in other nerve areas precede the deafness. In the majority, however, the latter forms the initial symptom of the tumour of the brain.

In unilateral tumours of the cerebellum, there is very often bilateral deafness, according to Schwartze, even when no direct pressure is exercised by the tumour on the nerve of the other ear.

I had an opportunity of witnessing an interesting case of right-sided deafness caused by a tumour in the right half of the cerebellum. The case was that of a waiter, 24 years of age, who had often suffered from headaches since childhood. He observed, in May, 1880, a decrease in the hearing-power of the right ear. Soon thereafter, he was attacked by headache, vomiting, weakness of sight, and, some months later, by paresis of the right facial, giddiness and tinnitus. In the beginning of September, after excessive vomiting, there suddenly set in unconsciousness and sopor, motor disturbances

in the muscles of the neck and of the upper extremities, gradual blindness, and several weeks later bilateral exophthalmos, decidedly stronger on the left side.

On examining the ears I found both membranes normal. The acoumeter was heard on each side on contact only, but much more faintly on the right side. Hearing for speech on the right = 0, on the left = $1\frac{1}{2}$ metre. Perception for the acoumeter through the bones of the head was weaker on the right side than on the left. High and low pitched tuning-forks were heard through the air faintly on the right side, but perfectly on the left; all tuning-forks were perceived from the vertex of the head by the left ear only.

In its further course, repeated violent vomiting, unconsciousness and general paralysis set in. Death ensued on the 19th November, 1880.

Post-mortem Examination.—The convolutions of the brain were greatly flattened, and the sulci effaced; the corpus callosum was much bulged out and fluctuant; the ventricles of the brain were enlarged to twice the normal size; the foramen of Monro was the size of a pea; the septum pellucidum was very thin and transparent, and there was a gap as large as a bean in its posterior half. The interior of the right hemisphere of the cerebellum was occupied by a cyst larger than a goose's egg, the upper, under and middle walls of which were formed by the substance of the brain 3mm. in thickness, while at the side of the hemisphere the cyst was bounded only by the arachnoid stretched over it. The inner surface of the cyst was lined by a very thin layer of transparent gelatinous tissue, which was most abundant towards the side of the hemisphere, and appeared pigmented in places or infiltrated with capillary hæmorrhages. The contents of the cyst were composed of a clear, aqueous serum.

With this case is classed a second, affecting a young man, aged 25, with scrofulous cicatrices on the neck, who had suffered for seven years from a discharge from the left ear, but whose hearing had been normal on the right side. Some months previously, dulness of hearing set in on the right side, with severe headache and weakness of sight. Two months previously total deafness suddenly occurred, which only gradually improved.

The result of the examination was: on the left, complete destruction of the membrana tympani, malleus and incus adherent to the inner wall of the tympanic cavity; on the right, the condition was normal. On account of the stupor of the patient, accurate testing of the hearing was impossible, and it could only be ascertained that speech on the right was understood at a distance of 3 metres, while on the left it was not understood at all; the low-pitched tuning-fork, from the vertex, could only be perceived on the right. Death ensued from marasmus and general paralysis.

Result of Post-mortem Examination.—The right half of the cerebellum was so greatly enlarged that the medulla oblongata and the inferior vermiform process of the cerebellum were displaced towards the left and flattened. The enlargement of the right hemisphere was caused by a cavity in its substance filled with a thin brown fluid, 8 to 9 cm. in diameter. The inner surface of the cyst was partly yellowish-white, partly brown, and smooth; but at one point there projected a somewhat nodular growth 4 cm. in length and about $\frac{1}{2}$ cm. in height, formed of a gelatinous, transparent tissue, not distinctly

demarcated from the surrounding tissue. The striæ acusticæ were on the right side indistinct, and on the left flattened. The ventricles of the brain were greatly distended by clear serum. The two auditory nerves and the optic tracts were diminished in size, transparent and gray.

The right ear was normal; the appearance of the left agreed with that recognised during life, and the ostium tympanicum tubæ was closed by an osseous plate.

Diagnosis.—Sarcoma of the right hemisphere of the cerebellum, with formation of a cyst-like cavity in the substance of the cerebellum, produced by the hæmorrhage.

The *diagnosis* of deafness caused by tumours of the brain is but seldom possible, particularly in that stage in which, beyond the disturbance of hearing, there are no symptoms of irritation or paralysis discernible in the areas of distribution of other nerves. At that time the differential diagnosis is difficult, as dulness of hearing, combined with tinnitus and attacks of giddiness, with a negative condition of the middle ear, may be occasioned by an affection of the labyrinth as well as by a central lesion. In both cases, high and low pitched tuning-forks, placed on the vertex of the head, are heard only by the normal or better-hearing ear. An important guide for the diagnosis of such cases is the early occurrence of facial paralysis, and the intact perception for the watch and the acoumeter through the bones of the head. While in affections of the labyrinth, even with only a moderate degree of dulness of hearing, perception through the bones of the head is either greatly decreased or quite absent, in disturbances of hearing caused by tumours of the brain perception is intact, and only defective when the dulness of hearing is very great. The perception for the high tones of the tuning-fork is diminished (Moos). According to Gradenigo (*A. f. O.*, xxvii.) the increase of electrical excitability of the auditory nerve with an intact ear is an important early symptom of tumour of the brain.

Further, the diagnosis is attended with great difficulty in the absence of other symptoms of cerebral compression, if an affection of the middle ear exists at the same time, which, as we have seen, may also run its course with vertigo and a staggering gait.

A case observed by me affords a striking example of this kind. It was that of a young woman, 26 years of age, who had suffered for years from suppuration of the left middle ear, combined with subjective noises and vertigo. After some months' treatment the ear-discharge was cured, and the patient was dismissed with a perforation in Shrapnell's membrane and an adherent cicatrix behind the handle of the malleus. Notwithstanding the great improvement in the hearing, tinnitus and vertigo remained unabated. When the patient presented herself at the clinic some months later, on account

of giddiness, increasing vertigo, and disturbances of equilibrium, suspicion was aroused as to the possible presence of a central lesion, but there was still the possibility of the phenomena being caused by increase of pressure in the labyrinth (in consequence of the adhesive process in the neighbourhood of the stapes).

The diagnosis of a tumour of the brain could only be made with certainty when the patient, some months later, was admitted to the general infirmary with bilateral weakness of vision, great dulness of hearing, and paresis of the extremities. In the course of several months she became quite blind and deaf, the paralysis of the extremities increased rapidly, and she died with symptoms of general paralysis.

Result of Post-mortem Examination.—In the triangle on the right half of the pons Varolii and the right crus cerebelli ad pontem, which is formed by the places of origin of the trigeminus, facial auditory, and abducent nerves, there was situated a somewhat nodular, oval, superficial tumour, the size of a goose's egg, proceeding from the meninges, which on section was whitish, transparent, and vascular, and enclosed some cysts of the size of peas filled with clear serum. By this tumour the right half of the pons Varolii, the right crus of the cerebellum and the right crus of the cerebrum were flatly compressed. In like manner the medulla oblongata, in the region of the right pyramid and olivary body and the anterior third of the inferior surface of the right hemisphere of the cerebellum, was compressed. Of the nerves, the abducens was displaced towards the middle, the trigeminus, facial and auditory run on the external surface of the tumour. The latter nerves were greatly compressed, their fibres being separated from each other.

In a case reported by Unverricht (*Fortschrift d. Med.*, 1887) of multiple cranial nerve paralysis from a round-celled sarcoma growing between the dura and base of the skull, which simulated the clinical appearances of a syphilitic sclerosis of the brain, an observable diminution of the hearing on both sides occurred only a few weeks before death.

The disturbance of hearing may be traced with more certainty to a tumour of the brain, when at the same time the already described signs of paralysis of other nerves present themselves. In cases not very advanced slight degrees of facial paresis and anæsthesia of the skin of the affected half of the head should be paid particular attention to, as they may easily be overlooked in a superficial examination.

Moos (*Virch. Arch.*, lxviii.) has communicated some cases of great deafness with coincident affection of the trigeminus, which he referred to a cerebral disease. The deafness was as a rule bilateral. The phenomena on the part of the trigeminus, which preceded those of the auditory nerve, varied from the most violent neuralgic pains to complete anæsthesia, always affected its sensory root, and were mostly unilateral. The auditory affection commenced with excessive subjective noises, which became, however, weaker with the increasing paresis of the auditory nerve, and completely disappeared with its total paralysis. The deafness was either sudden or showed a protracted character. Only in one case did recovery take place under the use of the constant current.

The occurrence of trophic disorders of the middle ear in consequence of intracranial affections has been proved by repeated clinical observations, and Benedikt and the author (*Wien. med. Woch.*, 1865) have pointed out the causative connecting-link between affections of the brain and of the middle ear. Recently Moos and Steinbrügge (*Z. f. O.*, xi.) have observed the formation of a pigmented membrane, extending over the whole of the mucous membrane of the middle ear, in consequence of hæmorrhagic pachymeningitis.

In favour of the occurrence of trophoneurotic disorders in the middle ear are the experiments of Gellé, Berthold and Baratoux, who observed inflammatory changes (hyperæmia and purulent exudation) in the middle ear after cutting through the central root or stem of the trigeminus. Kirchner and Aschenbrandt (*Festschrift Würzburg*, 1882) have recently proved experimentally that an increased mucous secretion in the middle ear is also caused by irritation of the trigeminus.

The occurrence of mental reflexes in consequence of diseases of the organ of hearing requires to be mentioned. Köppe (*A. f. O.*, vi.) was the first to draw attention to the fact that mental disturbances (melancholia, hallucinations, suicidal attempts, attacks of mania) may be reflexly called forth by pathological changes in the organ of hearing, in the presence of a congenital or acquired pathological tendency of the brain. Cases in which the existing psychosis is completely healed by removing a ceruminal plug, healing a middle-ear inflammation, or after removing a polypus (Schmiegelow) have been repeatedly reported in the literature. Ch. Delstanche succeeded, in a young girl who was hard of hearing, and suffered from frequent epileptic attacks, in completely curing the epilepsy by rarefying the air in the external meatus with his 'rarefacteur' (p. 80). From this it is shown that in neurasthenic, hysterical and mentally affected patients, who show symptoms of ear disease, the experiment should always be tried of possibly affecting the neurosis or psychosis by local treatment of the ear.

As to the connection of ear and eye affections, that is, as to the influence of the disease of one organ upon the other, the views of different persons vary. The statement by Urbantschitsch (*Pflüger's Arch.*, Bd. xxx.) that diseases of the ear may produce an alteration in the visual sense through the course of the trigeminus, according to my view will not stand the test. The simultaneous occurrence of eye and ear affections can be considered to be due to the same cause in most cases : atmospheric influence, scrofula, acquired and hereditary syphilis, etc. The increase of vision in some cases from therapeutic effect upon the ear is, according to my view, principally due to the effect of the peripheral irritation of the trigeminus upon the eye, and less to the effect of the improved function of hearing. If disturbances of hearing produce such deleterious effects upon the eye, then disturbances of vision would occur more frequently than they do, and we need only to consider the fact that most deaf and dumb persons possess acute vision and similarly most blind persons have acute hearing.

That reflex neuroses (fulness of the head, headache) may come from the middle ear has frequently been stated in describing middle-ear catarrh. Legal (*Ziemssen's klin. Arch.*, 1887) has called attention to the fact that frequently long-continued headache and hemicrania are produced by slight middle-ear

catarrhs which are scarcely observed by the patient, and are often rapidly healed by the inflation of air by my method, or with the catheter. Steinbrügge and Erb have shown that reflex neuroses may be produced by certain unexpected noises (clapping of hands, ringing of a bell, crack of a whip) in hysterical and neurasthenic individuals, even when the ear is normal.

Malformations of the Organ of Hearing.

The malformations of the ear are in so far of interest to the aurist, that they frequently form the foundation of deafness, *i.e.*, deafmutism. They either occur with malformations of other organs, or are confined to the organ of hearing. Of the latter the bilateral anomalies of formation are full of significance. The malformation affects only some parts of the ear, or the whole organ. Thus with an excessive malformation of the external and middle ears, the

FIG. 322. — AURICULAR APPENDAGE SEATED IN FRONT OF THE TRAGUS IN A BOY AGED 9 YEARS.

Removed. Healing of the united edges of the wound with a scarcely perceptible linear scar.

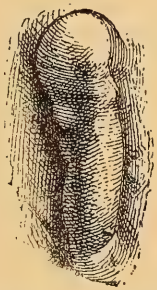

FIG. 323.—RUDIMENTARY AURICLE IN THE FORM OF A LONGISH CARTILAGINOUS TUMOUR.

internal ear may be normal, and also with arrest of development of the labyrinth, the tympanic cavity and the external ear may be perfectly formed.

Anomalies of formation of the auricle are very frequent, and exhibit either an excess or a defect of formation. Among the first are reckoned congenital excessive enlargement of the auricle, the occurrence of two (Knapp) or more (Cassebohm, Langer) auricles on one side (polyotia), and the so-called auricular appendages (Virchow) which project as isolated portions of cartilage in front of the tragus or beneath the auricle in the form of round or longish prominences (Fig. 322). Excessive formation is generally confined to the auricle, while arrest of development is as a rule combined with similar defects in the auditory meatus and the middle ear, less frequently in the labyrinth (Cassells). As anomalies of position of the auricle, its location upon the cheek, more rarely upon the neck, is to be mentioned.

Defective formation of the auricle occurs either as a total absence of it, or as a stunting and shrivelling of the cartilage, lastly as a malformation of one or other of its sections. The changes of form thus caused are manifold; the auricle appears sometimes as a rudimentary membranous swelling or cartilaginous cone, sometimes hook-shaped or spirally curved (Knapp), or rolled together like a cone (Zaufal, D. Hunt), or as a cauliflower excrescence (Moos and Steinbrügge); further as the so-called cat's-ear, and most frequently, as in Fig. 323, as a longish cartilaginous swelling. Congenital fissure of the lobe of the ear is quite common.

The greatest portion of anomalies of formation of the auricle are according to Rohrer explainable from the method of development of this organ. Insufficient closure of the two upper branchial clefts, insufficient turning up of the auricle during its growth, division or fissure of the foundation, etc., are the most important embryological sources.

Among the malformations of the external meatus must be mentioned the rarely met with excesses of development, such as immoderate dilatation and a double condition of the canal. In the latter anomaly there is, as in Velpeau and Macauln's cases (*Specialist*, London, 1881), behind the proper auditory meatus a second blind canal, without any connection with the other; or there may be two separate canals, which, as in Bernard's case (*Journ. d. phys. exp. de Magendie*, iv.), after a short course unite to form a common canal.

The branchial-canal fistulæ (fistula aur. congen.) must here be mentioned, which, according to examinations made by Urbantschitsch, Schwabach, Kipp, and Kratz, have no connection with the development of the auditory meatus. They appear as short blind canals, lined with epithelium, and secreting a milky fluid; they discharge by a roundish orifice in the skin, visible below or in front of the tragus, and they communicate neither with the auditory meatus nor with the tympanic cavity. Sometimes there follows a cystic enlargement of the branchial fistula. In several cases they were proved to be hereditary (Kratz). The anomaly is generally bilateral; in two cases observed by me it only affected the left ear.

The defects in the formation of the auditory meatus are more frequent, which are combined usually with defects in the auricle, with partial or entire absence of the middle ear, and often with arrest of development of the bones of the head (Mich. Jager, Moos and Steinbrügge, Zuckerkandl, and others). They take the form of congenital contractions, often of atresia, which is either osseous or membranous. Sometimes all sign of an auditory meatus is absent (Robb, *Am. Journ. of Otol.*, iii.; Hessler, *Stat. Ber. A. f. O.*, xvi.). In place of the external orifice of the ear there is either a shallow depression or a short blind canal (Welcker, *A. f. O.*, i.; Zaufal, *Prag. med. Wochenschr.*, i. Knapp, *Z. f. O.*, xi.).

In the case of a malformation of the right ear, dissected by me, besides a rudimentary auricle, I found the auditory meatus represented by a fibrous cord 1 cm. long, entire absence of the cavity of the middle ear, and the ostium pharyngeum tubæ indicated only by a small fossa. The osseous and membranous labyrinths were perfectly formed, and the expansion of the auditory nerve with Corti's organ was normal.

The most important malformations of the membrana tympani are the

following: congenital absence of the membrane, which always appears in connection with arrested development of the external auditory meatus and of the middle ear, and congenital perforations, which are observed at the anterior superior pole in the region of Shrapnell's membrane, generally bilateral and combined with cleft palate (v. Tröltsch).

A congenitally double condition of the membrana tympani appears doubtful, and it is probable that, in the cases described by Duverney, Giampietro, and others, a membranous new-formation in the external auditory meatus has been mistaken for a second membrane (Schwartze).

The most important anomalies of formation of the tympanic cavity are its rudimentary development with contraction to the diameter of the head of a probe (Moos and Steinbrügge, *Z. f. O.*, x.), and its complete absence. Besides these there occur partial defects of development, such as contraction (in a preparation of mine), or complete closure of one or both fenestræ of the labyrinth, and absence of the eminentia stapedii and stapedius muscle (Politzer).

The following malformations of the ossicles have been described; abnormal increase or decrease in size, coalescence of all the bones to form one (columellar formation, Toynbee), union of both crura of the stapes to form one common rod proceeding from the centre of its footplate, and the complete absence of one or more of the ossicula.

Malformations of the Eustachian tube are usually combined with those of the external meatus and of the tympanic cavity, sometimes also with cleft palate (Gruber). A congenital dilatation to 3-4 times its normal size has been described by Cock (*Med.-Chir. Trans.* xix., cited by Schwartze). Cassells (*Glasg. Med. Journ.*, April, 1876), besides contraction of the osseous auditory meatus, also found contraction of the osseous tube. Total absence of the Eustachian tube, with simultaneous absence of the external meatus and of the tympanic cavity, has been observed by Moos and Steinbrügge, and in one case by me also.

Along with partial or complete absence of the external and middle ears, there are, as a rule, also defects in the mastoid process, extending even to its entire absence (Michel, *Gaz. med. de Strasbourg*). Sometimes, even when the formation of the other parts of the temporal bone is normal, this process is so shrivelled as to form a short solid prominence.

Among the malformations of the internal ear, which occur either with simultaneous defects in the sound-conducting apparatus or with normal conditions of the latter, there have been described: complete absence of the labyrinth (Michel, Schwartze), absence of one or all of the semicircular canals (Bochdalek, Toynbee, Voltolini, Bremer, and others), rudimentary development of the same (Triquet), absence of the vestibule and of the cochlea (Montain), or of a single coil of the latter (Hyrtl), absence of the modiolus or of the lam. spiralis (Nuhn), incomplete development of Corti's organ (Scheibe), opening of the fenestra rotunda into the vestibule, dilatation of the aqueducts (Hyrtl), absence of the auditory nerve only with simultaneous absence of the labyrinth (Michel), and lastly, absence or imperfect development of the striæ acusticæ and of the nucleus of the auditory nerve. According to Steinbrügge defects produced by inflammation early in life may resemble congenital defects of the ear.

The above malformations of the internal ear are combined, as a rule, with total deafness. On the other hand, with defective development of the sound-conducting apparatus, and at the same time normal development of the internal ear, perception for sound is present in various degrees. In atresia of the external meatus hearing for speech may be present, which is affected either by means of the bones of the head or by the Eustachian tube.

In unilateral absence of the external and middle ears the state of the labyrinth on the same side can be ascertained by examinations with the tuning-fork. When the vibrations of the fork from the vertex are better perceived by the malformed ear, it shows that the development of the labyrinth is normal: when, on the other hand, the tuning-fork is only heard by the normal ear, it is probable that there is a defective development of the internal ear also on the malformed side.

In unilateral absence of the auricle, combined with atresia of the meatus, examination of the movements of the velum palati during phonation should never be omitted. If the movement of the palatine arches is symmetrical, it may with probability be inferred that the development of the Eustachian tube and of the middle ear is normal. If, on the other hand, the half of the palate on the malformed side exhibits diminished movement, as I have repeatedly observed, it may justly be assumed that the tympanic cavity and the Eustachian tube are defective, in so far as they are combined with a defective development of the muscular apparatus of the palate and tube.

Operative interference in congenital atresia of the external meatus is only allowable when it has been with certainty ascertained by careful examinations that it is a case of a congenital thin-walled septum at the entrance to the ear, when by applying the ear-trumpet to the closed part speech can be understood, and by catheterism of the Eustachian tube the stream of air can be heard in the middle ear by means of the otoscope. When the atresia extends far inwards, on the other hand, so that the auditory meatus cannot be made out, or only as a solid cord, operation must be avoided as irrational and dangerous.

Deafmutism.

The absence of the power of speech in consequence of congenital or acquired deafness is termed deafmutism. The most frequent causes of congenital deafness are: heredity, including direct transmission from the parents as well as indirect transmission from forefathers, and marriage between blood-relations.

Direct transmission, according to Hartmann's investigations, is on the whole rare. Much more frequent is indirect transmission, which has been proved by Hartmann in 68 per cent. of his cases. In this case there is transmission of a defective constitutional tendency, which must also be supposed to account for the occurrence of congenital deafness in several children of the same family, without apparent hereditary tendency. Kramer describes one family in which six sons were born deaf and five daughters with perfect senses, while the parents were both healthy. I myself saw in one family, in which there existed no hereditary disposition, four deaf-mutes out of ten brothers and sisters. The highest number of deaf-mutes hitherto observed in one family in which there was no hereditary disposition, was eight.

The statements of authors on the influence of close intermarriages on congenital deafness vary, for Boudin attributes the cause of deafmutism to consanguinity of the parents in 25 per cent. of the cases, Mitchell in 6 per cent., Hartmann in 8·1 per cent. Schmalz (*Ueber Taubstummheit im K. Sachsen*, Leipzig, 1884) disputes the supposed connection. Whether unfavourable social relations favour the frequent occurrence of deafmutism is questionable; the frequency of the imperfection is very marked among the inhabitants of mountain districts, and may probably be traced to the great number of their close intermarriages.

Acquired deafmutism is not so often caused by primary affections of the ear as by intra-cranial processes and general diseases. First in importance are epidemic cerebro-spinal meningitis, simple meningitis, and hydrocephalus; then the acute infectious diseases, typhus, scarlatina, diphtheria, measles, hereditary syphilis, mumps (Roosa), and, lastly, primary diseases of the ear, particularly inflammation of the labyrinth (p. 635), panotitis (p. 640), and traumatic injuries of the auditory nerve.

The numerical proportion of congenital to acquired cases of deafmutism varies according to the author and the country. The recent statement, that the two forms occur equally often, cannot be accepted as definite, as even by an accurate examination by a specialist in a series of cases, it cannot always be ascertained whether the deafmutism is hereditary or acquired. By thoroughly investigating 210 cases which he dissected, Holger-Mygind found 125 cases of acquired and 54 cases of congenital deafness; the etiology in the remaining 31 cases was undecided. That the data given in deaf and dumb institutions are quite untrustworthy, is seen from the fact that the author, in a number of cases said to be congenital deaf-mutes, has found changes in the ear (extensive perforations, adhesions of the membrana tympani, etc.), which showed without doubt that the deafmutism had been acquired. Schmalz came to the same conclusion. In 16·2 per cent. of the cases said to have been deaf and dumb from birth, he found objective changes in the ear; on the other hand, among those said to be congenitally deaf and dumb, in 39 per cent. no trace of any disease of the ear could be found.

According to Bircher, a distinction should be made between the sporadic

and the endemic occurrence of deafmutism, the latter of which always occurs with endemic goitre. Owing to the effect of the endemic disease virus, intra-uterine changes of the hearing and speech centres could occur which produce deafmutism. The endemic deafmutism may also be acquired during the first years of life.

According to Hartmann's excellent work *Taubstummheit und Taubstummenbildung*, from the statistics hitherto collected, among 10,000 inhabitants there were 7·77 deaf-mutes.—Of the separate countries, the Netherlands and Belgium were the lowest, with 3·35 and 4·39; and Switzerland the highest, with 24·5.—The number of deaf-mutes in the Austrian Alpine districts was particularly large; in Carinthia, among 10,000 inhabitants, there were 44·1; in Salzburg, 27·8; in Steiermark, 20·0 deaf-mutes.—The average number in Germany was 9·66 and in Austria 9·7.

The pathological anatomy of deafmutism is still very incomplete, notwithstanding the considerable number of post-mortem records. The changes, especially in the central course of the auditory nerve, forming the foundation of deafmutism, are almost unknown.

Holger-Mygind (*H. f. O.*, xxx.) has done the service to tabulate the result of dissection in 118 cases of deafmutism found in the old and recent literature. This allows a valuable comparison of the changes in the different portions of the ear in deaf-mutes.

As anatomical foundation of congenital deafness have been found: bilateral atresia of the meatus of the ear, insufficient development or exclusion of the middle ear, defects and rhachitic deformities in the fenestræ of the labyrinth (Moos), binaural osseous closure of the fenestra rotunda, with anchylosis of the stapes and narrowing of the labyrinthine cavity (Politzer), fissure-like narrowing of the niche of the fenestra rotunda with connective-tissue atresia of it (Politzer), lack of development in the labyrinth and in the course of the auditory nerve, intra-uterine inflammatory processes in the middle ear and in the labyrinth (Moos, Gellé, Politzer), anomalies of growth of the central nervous system, fœtal meningitis, and hydrocephalus.

The chief anatomical changes causing acquired deafmutism are: bilateral acquired atresia of the auditory meatus occurring in the first years of life, usually from scarlatinous diphtheria, purulent inflammation of the middle ear terminating in exfoliation of the ossicula, caries and necrosis of the labyrinth, tight adhesions and anchylosis of the sound-conducting chain, chronic non-purulent catarrh terminating in obliteration of the tympanic cavity by new-formed masses of connective tissue (Schwartze) and in anchylosis of the ossicula, ascending catarrh of the tube in children (Boucheron), inflammatory and retrogressive changes in the labyrinth, destruction of the membranous labyrinth and Corti's organ, neuritis of the

auditory nerve (Baratoux), and sequelæ of meningeal and cerebral processes in the auditory nerve and in the sinus rhomboideus.

It cannot always be decided from the anatomical conditions whether the deafness is congenital or acquired. Only with marked restrictions of formation in the ear can it be said that a case is congenital deafness with certainty. On the other hand, it is often impossible to say with a lack of reliable history whether certain changes—for example, anchylosis of the ossicular, hyperostoses on the fenestræ of the labyrinth, connective tissue and osseous new growths in the labyrinth—date from intra-uterine life or occurred after birth.

Holger-Mygind calls attention to the relative frequency of the diseases of the labyrinth and the frequent association of the semicircular canals.

Of the changes present in the labyrinth of deaf-mutes are to be mentioned: thickening of the membrane lining the osseous labyrinth, hyperostotic narrowing of the vestibule and semicircular canals, thickening of the vesicles of the vestibules, colloid degeneration of the nerve epithelium in the utriculus

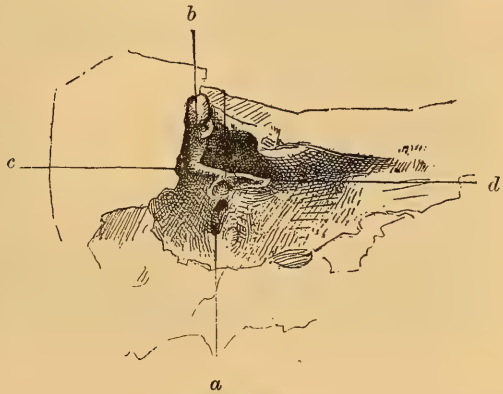

Fig. 324.

(Moos and Steinbrügge), partial or total obliteration of the labyrinth cavity through connective tissue and osseous new growth (Moos and Steinbrügge, Habermann, Burckhardt-Merian, Politzer), atrophy of the nerve termination in the cochlea (Scheibe) and in the ganglion layer of Rosenthal's canal (Politzer), defect in the organ of Corti and the changes already described after cerebro-spinal meningitis (Habermann).

Besides the anatomical changes already described by me in deaf-mutes, there still remain two interesting conditions to be mentioned. In a man 61 years of age, said to have been born deaf and dumb, the following conditions were noted: a normal state of the external and middle ears, the membrane of the fenestra rotunda very thin and very movable; hydrocephalus internus chronicus; pachymeningitis chronica; striæ acusticæ faintly developed; the stem of the left auditory nerve was gelatinously degenerated.—In a girl, eleven years of age, said to have been born deaf, I found the right membrana tympani cicatrized, the body of the incus (Fig. 324, *a*) embedded in masses of connective tissue, and the niche of the

fenestra rotunda (*b*) filled up with connective tissue. On the left side, in front of the malleus, there was an oval perforation 2½ mm. in size; the long process of the incus on both sides was one-third longer than normal, and was rectangularly bent in the middle (*c*).

The stapes was retracted backwards and upward, and its cruræ and head were adherent with the upper niche wall of the fenestra ovalis (in middle-ear sclerosis I always found anchylosis of the cruræ of the stapes with the lower niche wall). A nearly analogous condition was found in the dissection of another unknown deaf-mute. The long process of the incus with the head of the stapes were adherent to the posterior tympanic wall. By the change in position of the incus produced thereby, the space between the handle of the malleus and the long process of the incus appeared widened to a broad obtuse angle.—In a young deaf-mute who died in the poor-house, whose

FIG. 325.—FRONTAL SECTION THROUGH THE NICHE OF THE FENESTRA ROTUNDA OF A DEAF-MUTE. AGE UNKNOWN.

r, *r'*, Memb. fenestr. rotundæ; *n*, Slight depression at the place for the niche of the fenestra rotunda; *n*, *n'*, Narrow osseous fissure extending to the memb. fenestr. rot. filled with connective tissue containing fat.

history and age were not known, I found upon dissection: adhesion of the stapes with the posterior niche wall, and at the place for the niche of the fenestra rotunda was a slight depression. Microscopical sections of this place in a frontal direction showed (Fig. 325, *n*) a fissure running from the depression to the fenestra rotunda, filled with connective tissue in the meshes of which were fat-cells.

Whether secondary changes (atrophy from disuse) may arise in the sensory cortical centre of the temporal lobe in hereditary or long-continued acquired deafness, has not yet been ascertained. Luys is said to have found yellowish discoloration and colloid degeneration of the cerebral cortex with analogous changes in the auditory nerve.

When deafness is acquired within the first four years of life, dumbness almost without exception occurs. If deafness arise be-

tween the fourth and seventh years very frequently the power of speech is lost. Sometimes, however, in the case of intelligent children, who had already learned to read, it is possible, by careful attention on the part of those having charge of them, to ward off the development of dumbness. Deafness acquired after the seventh year seldom leads to dumbness.

When examining a deaf-mute it must be ascertained by a careful testing of the hearing whether total deafness exists for every kind of sound, or whether there is perception for noises and tones. With entire absence of perception of sound the deaf and dumb child will not move when loud sounds are made behind its back—for example, by clapping the hands, ringing a bell, whistling, blowing a trumpet, etc.—while with perception of sound the child will turn his head in the direction of the source of sound. The perception of sound through the bones of the head must also be tested by placing high and low pitched tuning-forks on the vertex and on the mastoid processes. In complete absence of perception of sound the features of the child's face remain unchanged; on the other hand, there is a slight smile when the tone of the tuning-fork is perceived.

If by the tests mentioned perception of sound is proved to exist, each ear should be separately tested as to the hearing of vowels and of speech. It has been observed that many deaf-mutes, and more frequently those deaf-born than those who have acquired deafness, repeat some vowels spoken into the ear, particularly *a*, *o*, and *u*, less frequently the consonants (oftenest *b*, *p*, and *r*). By long practice simultaneous touching of the external region of the ear appears to favour the perception of the vowels and consonants.

Toynbee, de Rossi, and Hartmann have examined the power of hearing in a large number of deaf-mutes, and according to the latter there were in 100 cases 60·2 per cent. with total deafness, 24·3 per cent. with perception of sound, 11·2 per cent. with hearing for vowels, and 4·3 per cent. with hearing for a few words. Schmalz, whose investigations were among the 1,726 deaf-mutes of Saxony, found in 21·4 per cent. complete lack of all sensation of sound, in 69·8 per cent. slight capability of perception, in 8·8 per cent. no positive result could be obtained. According to the statistical material of Holger-Mygind, total lack of perception for sound is present in only a small proportion of deaf-mutes, and is observed more frequently with acquired than with congenital deafmutism.

Kreidl (Pflüger's *Archiv*, li., p. 119) found among 109 cases examined, that in scarcely 50 per cent. was that oscillating movement of the eyes absent, which is always produced in a normal person by turning on a vertical axis, and, according to the theory of static sense, is reflected from the semicircular canals. Kreidl considers, therefore, that the semicircular canals are diseased in scarcely 56 per cent. of deaf-mutes, that in these the eye movements are

lacking, and dizziness occurs. Of 62 deaf-mutes who were turned around in a 'carrousel,' only 13 were able to locate the vertical (placing an indicator), while this was possible in all but 1 among 71 healthy persons. The absence of this sense is present with destruction of the otolith apparatus, and shows that it allows us to judge of our position in space. That explains also the other actions of deaf-mutes, who walk with the feet wide apart, and upon closing the eyes, cannot safely stand upon one foot, or maintain an upright position.

In my experience the *prognosis* of congenital deafmutism is more favourable than that of the acquired. In a considerable number of cases, in which I had ascertained in childhood the existence of congenital total deafmutism, several years later there was observed development of hearing for speech at a distance of $\frac{1}{3}$ to $1\frac{1}{2}$ metre, or more. In most cases this improvement appeared in one ear only, while the other remained deaf. Hartmann also relates the case of a girl, born deaf, whose hearing spontaneously improved so much that she could understand words spoken directly into the ear.

I have only observed complete cure in one case. It was that of a boy, 3 years of age, who was examined in 1862 and found to be deaf-mute with no perception of sound. In his sixth year, however, the child was presented by his mother, with the information that his hearing had gradually developed within a year, and that he now heard quite well. On careful testing I indeed found normal hearing on both sides, but speech was faulty and indistinct. When I was consulted in 1878 by the youth, then 19 years of age, I found normal hearing on the right side, but on the left the membrana tympani was perforated in consequence of suppuration of the middle ear of a year's duration; the hearing-distance for the acoumeter was $\frac{1}{3}$ metre, for whispered speech 1 metre, and for speech normal.

On the other hand, I have not observed improvement in the hearing in a single case of total deafness acquired in consequence of scarlatina or diphtheritic processes of the middle ear, or after meningitis and hydrocephalus.

The question of *treatment* of deafmutism can be raised only in those cases in which the objective symptoms of disease of the middle ear are pronounced. In those forms especially in which, in consequence of a congenital middle-ear catarrh or one which had occurred in the first year of life and been overlooked, such a high degree of deafness had developed that the learning of speech had become impossible, favourable results were obtained by Politzerization methodically employed (Boucheron). My experience in this way agrees with similar observations of other specialists. Therefore, in deaf children with a highly concave membrana tympani or signs of an accumulation of mucus in the middle ear, inflations should be immediately tried, and only discontinued when no result

is obtained after several weeks' treatment. Jacquemart (*A. f. O.*, xxi.) secured healing in a child who was completely deaf and dumb, and in whom there was opacity and retraction of both membrana tympani, by the inflation of air though the catheter continued for some time. In deafness caused by scarlatinal and diphtheritic ulcerative processes in the middle ear and labyrinth, by panotitis, and by intracranial diseases, all treatment remains fruitless.

Of great importance for the education of deaf-mutes is the systematic deaf-and-dumb instruction, commenced as a rule in the seventh year. By that means the deaf-mute acquires not only the power and faculty of expressing his thoughts both by speech and by writing, but also receives a certain degree of mental culture. By careful training this is the more easily obtained, as the majority of deaf-mutes are well endowed mentally.

The Spanish priest, Pedro Ponce, who lived in the second half of the sixteenth century, is said to have been the founder of the teaching of the deaf and dumb. In 1778 the Abbé de l'Epée in Paris, and Heinicke in Leipzig, founded deaf and dumb institutions. The education by means of loud speech, which has been principally developed in Germany and Austria, has lately been more extensively introduced into other countries, while the methods with signs and gestures is only used to a limited extent. The congresses of deaf-mutes which took place within the last decade have decided that loud speech is the only proper method of educating deaf-mutes.

Some deaf-mutes learn to speak so distinctly that they can without difficulty be understood by everyone. Others, again, speak so indistinctly that it is only by great attention and constant intercourse with them that their meaning can be gathered. Even in the case of those who can be easily understood there is an unpleasant harshness of utterance, as the deaf-mute has no guide to the modulation of his voice. This is usually very marked in the case of those who are totally deaf, while those who possess in a slight degree perception for sound, for vowels, or for speech, can speak more intelligibly and less unnaturally.

Hearing-Instruments for the Deaf.

The hearing-instruments which are used in the many forms of excessive dulness of hearing aim at collecting the sound-waves, and conducting them in a concentrated form to the ear, thereby rendering social intercourse more easy.

The apparatus is the more effective the greater the surface by which the sound-waves are caught and reflected on the membrana tympani.

For conversation between two the best thing is a tube, $\frac{2}{3}$ to 1 metre long, made of a closely-compressed spiral wire encased in a layer of leather, and covered with a closely-spun woollen tissue

(Fig. 326). Its olive-shaped ear-piece for insertion into the external meatus is either straight or angularly curved. Its mouth-piece has the form of a cup or of a common speculum. Conical hearing-tubes, decreasing from the mouth-piece to the ear-piece, are more effective than those of the same width all through. In using the tube the mouth-piece is brought close to the mouth of the person speaking, and, as a rule, the usual tone of voice is loud enough to be heard by the listener. Too loud speaking cannot be borne, on account of the generally coincident hyperæsthesia acustica and the giddiness in the head.

Ear-trumpets or funnel-shaped instruments (30-50 centimetres in length) made of metal are not so good for near conversation, on account of the metallic sound the voice acquires. This unpleasantness is done away with in instruments made of vulcanite, which, when made in several pieces fitting together, on account of their light weight may be carried in the pocket.

For hearing at greater distances, trumpet-shaped tubes with wide mouth-pieces directed forwards, or paraboloid hearing-cups, are

Fig. 326.

better suited. These consist (Fig. 328) of a parabolic metal cup, from the focal point of which the sound-waves are collected by a second sound-collector projecting into the cup, and connected with the ear-piece. Fig. 329 is a modification of the same instrument, with two parabolic bowls turned against each other, and provided with a long ear-piece. Good service is given in many cases by Burckhardt-Merian's 'tragus hearing-trumpet,' in which the reflection of the sound outwards is prevented by a metal plate at the orifice. The hearing-trumpet made by Jos. Leiter of Vienna from hard rubber consists of a doubly-curved sound-receiver (Fig. 327), on the upper end of which is attached a short, flexible hearing-tube, with a movable tip on the end for the external meatus. The instrument has the advantage that the larger portion made of hard rubber can be put in the side pocket, so that it is less conspicuous than other instruments of this kind. Within the last few years smaller instruments have been made on the same principle, connected with

the upper end of a cane (Leiter) or umbrella, in order to render their use less noticeable.

The so-called otophone is only of little value. It consists of two bent strips of spring metal, by laying which on the mastoid process the auricle is raised from the surface of the head, and directed towards the waves of sound which come from in front. The concave hearing-vessels made of hard rubber (Leiter) are more useful, but are, however, only used by women. The sound-condenser is placed above the edge of the auricle, and may be hidden by the hair, cap, or hat.

From the great variety of hearing-instruments and their markedly

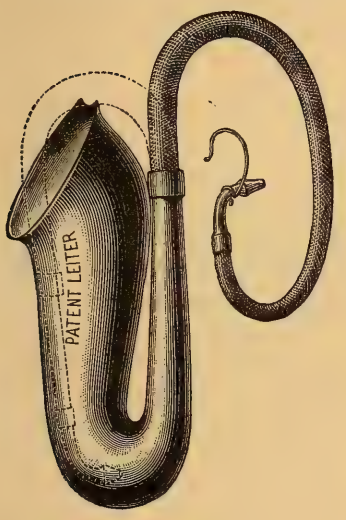

Fig. 327.

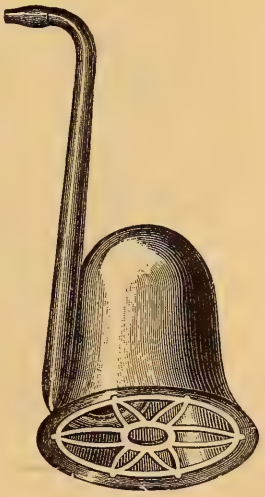

Fig. 328.

Fig. 329.

different effects in one and the same individual, in any case in which such an instrument is required it is best to let the patient try a number of them, and then choose the one with which he hears best. It has already been mentioned that many persons very dull of hearing can hear better without an ear-trumpet, therefore through the bones of the head, than with one.

The number of those who prize ease of social intercourse so highly that they pay no regard to the discomfort and conspicuousness of large ear-trumpets is very small. Notwithstanding the advantages possessed by large instruments, they are generally discarded on account of conspicuousness in use.

The ideal of all deaf people has always been a small instrument which could be worn unobservedly in the ear, and render at the same time the same

service as the largest instrument. This problem has not yet been solved, and will not be so easily.

The small instruments, recommended under so many different names, of which Abraham's is best known to the public, have proved utterly worthless.* They consist of a straight, short, narrow, silver tube, with a flat funnel-shaped extremity. Such tubes, as v. Tröltsch rightly observes, serve only one object, that of dilating or keeping open a very contracted cartilaginous meatus. With a normal width of the auditory meatus they are absolutely of no use; but they very often give rise to a decrease in the hearing-power by contracting the lumen of the meatus. The experiment of putting a miniature microphone into the interior of such tubes has been a failure. Of as little value as the straight ones are those variously constructed spiral and coiled tubes, of which the 'Apparitor Auris' has been especially recommended by an American, named Tiemann. In all those instruments there is a want of a physical or physiological principle as a basis for the concentration or the strengthening of sound.

By some casual experiments in the domain of physiological acoustics, I was led to the construction of a small hearing instrument, by the use of which in a number of deaf people a considerable improvement in the hearing was ascertained.

In principle it was based on the fact that a source of sound acting on the ear is heard more loudly when the surface of the tragus is enlarged towards the back by the application of a small solid plate.

The instrument constructed by me only aimed at enlarging the surface of the tragus backwards, in order to lessen, if possible, the loss of sound-waves arising by reflection outwards from the concha, *i.e.*, to conduct a larger proportion of sound to the auditory meatus than is done by the naked ear.

The small instrument (Fig. 330) has the form of a hunting-horn, whose narrower inner end (*a*) is inserted into the auditory meatus, while its outer broader part lies on the auricle so that its opening (*b*) is directed straight back against the concha. The size of the instrument varies according to the width of the auditory meatus, and the size of the auricle or concha. Three different sizes are sufficient for all cases. The larger instruments measure 2½ cm. in length, 12 mm. in diameter at the outer opening, and 5 mm. at the inner. The smaller ones are about 2 mm. less, and the smallest 3 mm. The external segment of the tube is cut away on the concave side to the extent of ⅓ of its circumference. At first I had them made of glass, but now of red vulcanite. The instrument is introduced as follows: with the wider opening

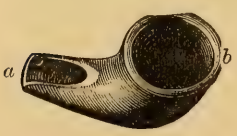

Fig. 330.
Actual size.

* See Schwabach's article, 'Hörröhren,' in Eulenberg's *Real-Encyklopädie der medicin. Wissenschaft.*

pointing upwards, the small end is pushed into the external meatus, and then it is turned in the auricle so that the large opening looks backwards towards the concha, and is pushed towards it.

With regard to the amount of improvement in the power of understanding speech caused by the application of this instrument, according to the experiments hitherto made, the hearing-distance, on an average, is at least doubled. In more than one-fourth of the cases it had no influence on the hearing-distance; in several cases it caused a decrease.

For a number of years I have used in persons who were hard of hearing an instrument I devised, the principle of which depends upon the vibration of the cartilaginous plate of the auricle being

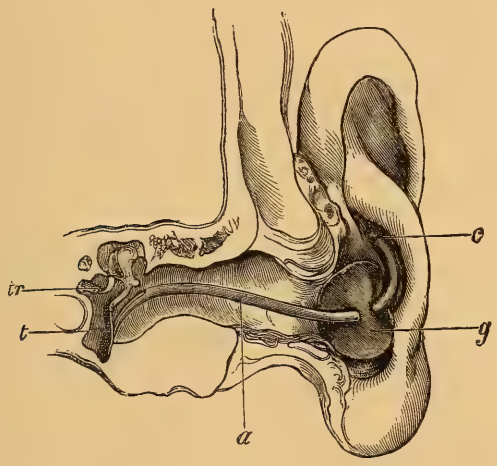

Fig. 331.

transmitted by an elastic sound-conductor to the membrana tympani.

It consisted of rubber tube (drainage tube) 4-5 cm. long, and 2 mm. thick; its clipped inner end (Fig. 331) being brought into contact with the membrana tympani (*t*), while the outer end (*c*) in the concha is in contact with the cartilage of the auricle. The effect of the instrument is increased by a round rubber plate placed near its outer end. The improvement in hearing produced by this instrument is occasionally 4-5 times the former hearing-distance. It is of most benefit in middle-ear catarrh with flaccidity of the membrana tympani; it is entirely without benefit in rigidity and anchylosis of the ossicula.

In the last decade different apparatuses have been constructed, which will be shortly described here.

Rhodes's audiphone, the beneficial effect of which depends upon the intensified sound-conduction through the cranial bones, consists of a flexible plate of vulcanite or pasteboard well lacquered, 25-30 cm.

long and 20-25 cm. broad, in the form of a four-cornered spade or fan. The lower margin is for the handle, the upper one is provided with a little metal plate for laying on the teeth or on the zygoma. By pressing the instrument on the anterior upper row of teeth, a curved surface with its convexity forwards is formed, from which the sound-waves falling on it are conducted through the bones of the head to the labyrinth.

For more convenient management, audiphones are being constructed in separate pieces, jointed together, which receive the necessary curvature and tension by means of a silk cord (Turnbull). A piece of moderately thick pasteboard often serves the same purpose.

The results obtained by the audiphone have not fulfilled what was expected of it. Extensive trials have been made by Knapp, Lennox-Brown, Joly (Lyon), and others, who affirm that the audiphone only effects marked improvement in a small percentage of cases of excessive hardness of hearing, and that its effect is far inferior to that of the ear-trumpet (Knapp).

That statement I can confirm from my own experience. The audiphone is most effective in deafness after exhausted suppuration of the middle ear, less effective in the sclerotizing inflammations of the middle ear. In the latter I have repeatedly observed striking improvement in the hearing from use of the hearing-plate. In affections of the nerve the improvement in hearing is seldom marked.

The hearing instruments lately constructed, in which the sound is transmitted through a stretched rubber membrane, has the advantage over the ordinary hearing-tube (Fig. 326) that the introduction of the hard ear-tip into the external meatus, which is often unpleasant, is avoided. This instrument (Leiter in Vienne) consists of a covered conical hearing-tube, with a funnel-shaped mouth-piece, the aural end of which has a cap, with an opening 3 cm. in size. In this cap, which consists of two pieces that screw together, is stretched a rubber membrane, the tension of which can be changed by the screw. During the conversation the tip is laid on the auricle, so that the opening comes opposite the external meatus. Another advantage of this instrument over the ordinary hearing-tube is, that with the latter the waves of sound entering the ear directly are very unpleasant to deaf persons who are frequently afflicted with hyperæsthesia acustica, while with the rubber membrane this unpleasant effect is avoided.

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THE END.

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Marked Parts

Catarrh of Mid. Ear. p253

Secretive

Adhesive

Dis. of Aud. Nerve Aparat 610 - 645